BULLETIN OF MARINE SCIENCE
OF THE GULF AND CARIBBEAN

VOLUME 11 1961 NUMBER 4

NORMAL STAGES OF THE EARLY DEVELOPMENT OF THE FLYING FISH, *HIRUNDICHTHYS AFFINIS* (GUNTHER)

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ABSTRACT

The embryology and early larval stages of the flying fish *Hirundichthys affinis* (Günther) are described. Eggs and larvae show developmental features of a demersal marine teleost and are only secondarily pelagic.

INTRODUCTION

The flying fish, *Hirundichthys affinis* (Günther), is one of the main sources of animal protein available to the population of the island of Barbados. There is no detailed account of the embryology of this species of the Exocoetidae available. The only papers concerned with the embryology of this group are a study by Miller (1952) which deals only with development up to the closure of the blastopore and a description by Nayudu (1923) of the embryo of a *Cypselurus* from the Indian Ocean at a stage equivalent to the 36-hour embryo of *H. affinis*.

References to the larvae are very scattered and are discussed to some extent by Hubbs and Kampa (1946) and Breder (1938). The only figures of young *Hirundichthys affinis* were found in Breder (1938) in which young fish measuring 27 mm, 37 mm, 44 mm, 67 mm, 85 mm and 137 mm are discussed.

The eggs of the Exocoetidae have attracted some attention. They are surprisingly variable in size and structure. Breder (1938) has stressed the taxonomic importance of a study of these eggs and Hubbs and Kampa (1943) have prepared a key for the identification of the eggs of flying fish and other Synentognathidae.

The sargassum-weed fish "nest" is discussed by Gudger (1937). This nest was originally thought to have been made by an antennariid that lives in the weed, but is now known to be produced by several species of flying fish, including *H. affinis*.

The following report deals with the development of the flying fish

from the freshly fertilized egg to the young fish about 10 days old and about 15 mm long.

The author is indebted to Dr. N. J. Berrill of the Department of Zoology, McGill University, for encouragement and critical advice; to Dr. J. B. Lewis of the Bellairs Research Institute, Barbados, for advice and help in field work and to Dr. Anton F. Brunn, Copenhagen, for checking the identification of the parent fish. The work was supported by a Colonial Development and Welfare Organization grant in aid of research.

Methods

The methods of catching flying fish have been covered in works by Hall (1955) and Hornell (1923). In this study all fish were caught on a nylon line baited with either crab or fresh flying fish. The freshly caught fish were stripped by squeezing the abdomen with a downward motion. If the fish were in running condition, the gametes flowed freely from the vent. When a ripe male and female were caught at the same time, the gametes of each were added to a bottle of sea water and fertilization ensued. The parent fish were labelled and fixed in formalin. These fish were sent to Dr. Anton Brunn who very kindly checked the author's identification of the species.

It was found, as Hall (1955) has noted before, that males were in running condition earlier than females. Females with nearly mature eggs would release upon stripping, but these nonviable eggs could easily be distinguished from mature eggs because they did not form the clump typical of the latter. This is due to the fact that the filaments which usually hold the mature eggs together in a mass were still tightly wrapped around the immature egg, making it look like a small ball of twine and preventing it from attaching to other eggs.

Four sets of eggs were obtained on three different dates. Two clusters of eggs were collected on May 20th, 1958, fertilized immediately, and from this culture, eggs and embryos were fixed every six hours, starting with the six-hour stage, and preserved for later study. On June 9th and July 12, 1958, two other clusters of eggs were collected, fertilized and used for live observations, rough drawings and photographs.

The eggs were incubated in 4 x 4-inch glass cylinders open at the upper end and sealed at the bottom by a piece of plankton silk held in place with a rubber band. The containers were kept three-quarters submerged in a table of running sea water. With this handling the

eggs seemed to develop to hatching quite normally with a mortality rate of ten to fifteen per cent.

The temperature at which the eggs developed in the laboratory (26° C plus or minus 0.5°) differed slightly from the temperature at which they normally develop in the sea (28° to 29° C). The difference is probably due to the fact that under normal conditions the eggs develop at the surface of the sea which is almost always brilliantly sunlit during the day, whereas in the laboratory the water and eggs were always shaded. The somewhat lower temperature probably increased the time required for hatching and may possibly have resulted in less pigmentation than is usual under natural conditions.

Considerable difficulty was encountered in raising the larval fish and this was probably due to improper feeding. As the yolk sac disappears at about 24 hours after hatching, active feeding must begin very soon. On the first two occasions the newly hatched larvae were kept in sea water to which was added a suspension of sea urchin eggs. All the young fish died within four days. On the third attempt a large number of brine shrimp larvae were kept with the young fish from the time of hatching. On this occasion growth was rapid and one fish was kept alive for thirteen days.

The eggs and larvae were preserved in five fixatives; 5 per cent saline formalin, Stockard's solution, Stockard's solution plus 0.5 per cent Tergitol, Bouin's fixative and Bouin's solution plus 0.5 per cent Tergitol. The Tergitol was very kindly supplied by the Carbide and Carbon Chemicals Company and as it is a strong detergent it was hoped that it would increase the permeability of the zona radiata to fixatives. However, no difference was noted in the fixing properties of either pair of solutions.

Formalin produced much distortion of both egg and embryo and was used only in the preparation of specimens for somite counts. Stockard's solution resulted in the most life-like preservation of whole mount material. The yolk remained crystal clear and the embryo became an opaque white. However, it caused the yolk to swell slightly so that the embryo became squeezed between the zona radiata and the expanding yolk and was eventually pushed down into the yolk mass. As a histological fixative, Stockard's solution was unsatisfactory.

Bouin's solution was a very satisfactory fixative histologically but gave poor results on whole mounts. It caused the yolk mass to shrink

to about two-thirds its normal volume which resulted in a secondary distortion of the embryo. However whole embryos fixed in Bouin's solution were useful for observing certain features such as the degree of pectoral fin development and the extent to which the tail had lifted off the yolk.

Whole mounts were drawn with the aid of a camera lucida and photographs of living eggs were used to correct for the distortions caused by fixation.

Composite drawings of the whole embryo were usually made from eggs fixed in Stockard's solution. Little success was met with in attempting to remove the embryo from the yolk and flatten it under a a cover glass as the tissue was too delicate and brittle. Instead, four or five drawings were made with a camera lucida of different regions of the embryo on the yolk. These drawings were then pieced together to form a composite.

In the study of larval and post-larval stages a careful search was made for cartilage. The metachromatic stain, Azure A, was used for this purpose on specimens preserved in Stockard's solution. The young fish were dissected and the parts thought to contain cartilage were stained.

Transverse and longitudinal serial sections were made of Bouin-fixed embryos at the ages of 36 hours, 48 hours, hatching, and 7 days after hatching. Sections were cut in paraffin at 7μ. Difficulty was encountered in removing the embryo from the yolk with the heart and digestive tract intact. Consequently in the first three stages these structures could not be adequately studied or described. Sections were stained in fast green and phloxine.

Description of the Normal Development of the Eggs of *Hirundichthys affinis*

The egg of *H. affinis* can be identified to species using the key provided by Hubbs and Kampa (1946). The mature egg, enclosed in its zona radiata, measures 1.6 mm in diameter plus or minus 0.1 mm. The yolk is a clear, light yellow fluid with no oil globules present in the early stages. The zona radiata is a perfectly transparent, very tough, elastic membrane. As in most species of flying fish and their relatives the zona radiata bears a number of filaments.

There are two clumps of filaments restricted to opposite poles of the egg. At one pole the filaments are short and fine and resemble a piece of wool stuck to the egg. At the other pole are a set of long,

thick filaments. In a count of eighteen eggs the number of larger filaments ranged from 8 to 14 with an average of 11. The large filaments arise from the zona radiata in a fairly definite pattern. All but one, the central filament, form a circle of uniform radius around the central filament which is larger in diameter than the others by about a half. The filaments are thought to be extensions of the zona radiata. The base of each filament is swollen in the shape of a truncated cone and under proper lighting a cross line is visible between the cone and the filament proper. Whether this line represents an internal structure or merely a superficial fold is not certain. In the living egg when one tried to pull off a filament by force, either the egg broke or, after considerable stretching, the filament broke somewhere along its length. In the fixed material, however, the filaments were easily pulled off the egg and the break nearly always occurred at the junction of the filament and the cone-like base.

The length of the long filaments was not measured since the distal ends were nearly always tangled. However, some were at least 4 cm long. Besides being very strong and elastic, the large filaments were quite adhesive and readily stuck to and tangled with any other eggs or weed with which they came into contact.

The function of the long filaments appears to be to hold the eggs from a single female together in one mass and to attach these eggs to some object floating at the surface which will act as a buoy. Sargassum weed is most often used by fish breeding under normal conditions. Whether or not the small filaments have any function could not be determined. They did not seem to tangle with other filaments.

Miller (1952) working on a species of *Cypselurus* which has much the same filament pattern as *H. affinis,* noted that in all cases cell division took place immediately under that portion of the zona radiata where the smallest and thinnest group of filaments was attached. The larger filaments were at the vegetal pole and served to attach the egg to the main string. In *H. affinis* the relationship between the filaments and the poles of the egg appears to vary and there is no physical connection between the embryo on the yolk and the zona radiata and its filaments. The orientation of the egg within the zona radiata appeared to be due to gravity, the blastodisc always lying below the yolk no matter how the egg as a whole was oriented in relation to the filaments. However, since the eggs sink in sea water and are attached to the main string only by the large filaments it would seem natural that the eggs would hang downward from the point of attachment of these

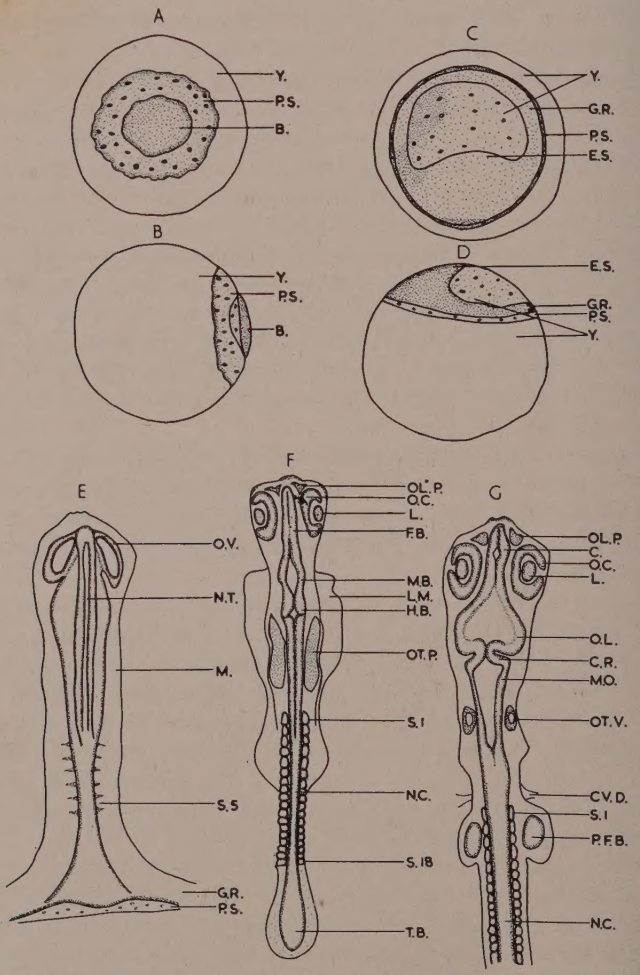

FIGURE 1. A and B: Stage A, 6 hours old. C and D: Stage B, 12 hours old. E: Stage C, 18 hours old. F: Stage D, 24 hours old. G: Stage E, 30 hours old. SYMBOLS: B.—blastodisc, C.—cerebrum, C.R.—cerebellum, CV.D.—Cuvierian duct, E.S.—embryonic shield, F.B.—forebrain, G.R.—germ ring, H.B.—hindbrain, L.—lens, L.M.—lateral mesodermal plate, M.—mesoderm, M.B.—midbrain, N.C.—nerve cord, N.T.—neural tube, O.C.—optic cup, OL.P.—olfactory placode, O.L.—optic lobe, OT.P.—otic placode, OT.V.—otic vesicle, O.V.—optic vesicle, P.F.B.—pectoral-fin bud, P.S.—periblast syncytium, S.—somite, T.B.—tail bud, Y.—yolk.

filaments with the blastodisc on the lower side of the egg, opposite the point of attachment of the small filaments.

The normal development of *H. affinis* was divided into a number of arbitrary stages described below. For each stage, the age, somite number (if any) and general morphological features are given. Most emphasis is laid upon the morphology. Somite number, besides being difficult to determine with accuracy, tends to vary among individuals at any particular stage of development. The chronological age also gives no true picture of development since growth of the egg is affected by the physical environment, which is difficult to maintain constant.

Stage A.—About 6 hours old; a late blastula (Fig. 1, A and B).

This is the earliest stage preserved and studied. The embryo is a late blastula, and individual cells of the blastodisc have become too small and numerous to count. The blastodisc lies flat, is lenticular in shape, and is just beginning to spread out over the yolk. It seems to consist of a thick, homogeneous mass of cells. Beneath the blastodisc and extending out on all sides can be seen a single layer of very large nuclei which lie in the periblast syncytium.

Stage B.—About 12 hours old; early gastrula (Fig. 1, C and D).

By this time the blastodisc has spread out over about one-quarter of the yolk mass and is no longer of homogeneous thickness. The central portion has become quite thin while the margin is considerably thicker. The thin central area will form the yolk sac ectoderm and the thick ring, the germ ring. One portion of the ring, thicker than the rest, is the embryonic shield. The periblast can be seen as a thin rim outside the germ ring.

Stage C.—About 18 hours old; five somites (Fig. 1, E).

The blastoderm now covers more than three-quarters of the yolk mass. The embryonic shield has elongated and narrowed and early differentiation of the embryo has started.

The neural keel can be seen as a median thickening running most of the length of the embryo and anteriorly it is folded as the neural tube. The optic anlagen have formed as out-pocketings of the fore-brain and are just beginning to vacuolate. The lateral mesoderm plate can be clearly seen along the sides of the embryo. In the posterior region of the body it has become organised into five somites. The layer of lateral mesoderm continues, behind the somites, to merge with the germ ring.

Large periblast nuclei can be seen scattered over that part of the yolk which is covered by yolk sac ectoderm but not by mesenchyme. In later stages the periblast nuclei become progressively more difficult to find. The cells at the posterior end of the embryo show no organization and tend to merge with the germ ring.

A curious little refractile bubble was observed in the yolk just under the tail. It was also seen in the 24 hour embryo but at no later stage. It probably is not Kupffer's vesicle but rather the yolk vesicle which Summer (1900) describes as occurring in the Stone Cat, *Notorus*. The yolk vesicle is a larger structure and appears earlier than Kupffer's vesicle. They develop in the same region and are said to have the same function as embryonic organs of digestion.

Stage D.—About 24 hours old; eighteen somites (Fig. 1, F).

By this stage the blastopore has closed. A side view of the embryo shows that it has lifted itself somewhat above the surface of the yolk. Only the posterior tip of the tail remains embedded in the yolk.

The brain is now definitely vacuolated and is becoming divided into forebrain, midbrain and hindbrain. The midbrain is just beginning to expand to form the optic lobes. The optic vesicles have invaginated and lens placodes are forming. A hollow optic stalk joins the optic vesicle to the forebrain. The olfactory placode is compressed between the anterior median edge of the eye and the forebrain. The auditory placodes show as large masses of cells lateral to the hindbrain. Anterior to the head the yolk-sac epithelium develops a cavity, which according to Oppenheimer (1937) is the first indication of the extra-embryonic coelom. It probably becomes the pericardium. The heart, a small tube under the mid-brain, starts to beat at about this time.

Stage E.—About 30 hours; 35 somites (Fig. 1, G).

At this stage almost the whole embryo has lifted itself above the surface of the yolk. About 35 somites can be counted and the embryo is wrapped more than half way around the yolk. The tail has not yet begun to flex.

The first sign of pectoral fins can be seen as cell aggregates just lateral to the first two or three somites.

The pericardium is distinct and large and the heart is beating steadily. At the ages of 34 hours, 40 hours and 73 hours, a count was taken of the number of heart beats per minute at 26°C. At all these stages the average was about 166 beats per minute, plus or minus 4 beats. No vitelline circulation could be seen at this time although it

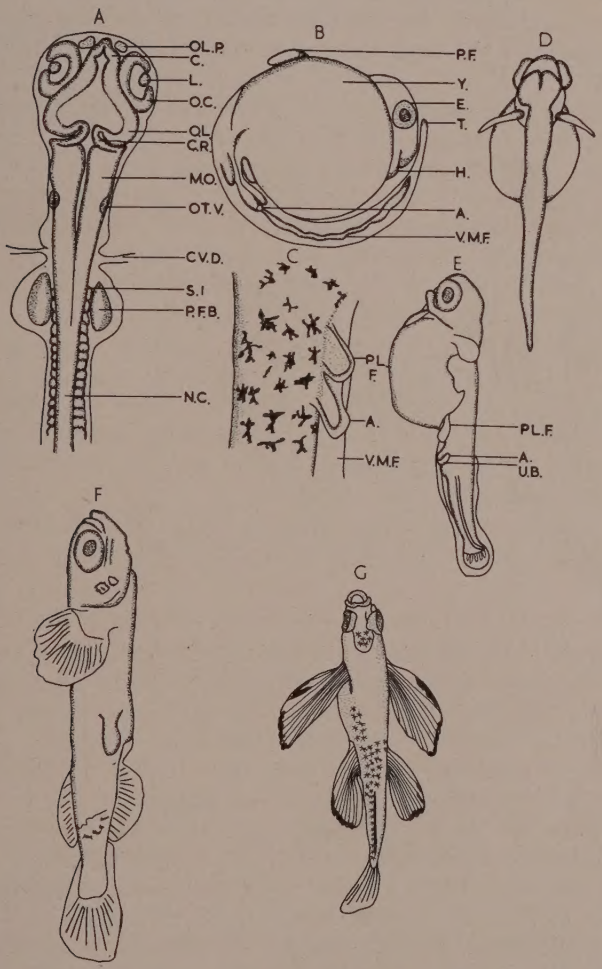

FIGURE 2. A: Stage F, 36 hours old. B and C: Stage H, 72 hours old. D and E: Stage I, hatching stage. F: Stage J, young larva. G: Stage K, 7-10 day old larva. SYMBOLS: A.—anus, C.—cerebrum, C.R.—cerebellum, CV.D.—cuvierian duct, E.—eye, H.—heart, L.—lens, M.O.—medulla oblongata, N.C.—nerve cord, O.C.—optic cup, O.L.—optic lobe, OL.P.—olfactory placode, OT.V., otic vesicle, P.F.—pectoral fin, P.F.B.—pectoral fin bud, PL.F.—pelvic fin, S.—somite, T.—tail, U.B.—urinary bladder, V.M.P.—ventral median fin, Y.—yolk.

is possible that a clear, acellular plasma was circulating. The first sign of the two large Cuvierian ducts can be seen on the yolk emerging at right angles from the embryo between the otic vesicles and the pectoral fins.

A short distance anterior to the head there is a mass of oil globules and cells. This mass seems to have migrated from the tail region of the embryo over the yolk toward the head. By the following stage it has reached the head. Stockard (1915), although he does not mention this particular phenomenon, does state that the most active point of mesenchyme migration is at the distal end of the tail. It can be seen that this area is quite broad and diffuse. The mesenchyme will form chromatophores, blood islands and vitelline blood vessels.

The brain has grown a great deal. The forebrain is just beginning to expand to form the cerebrum. The midbrain has enlarged to form the prominent optic lobes. The hindbrain can now be differentiated into the cerebellum, a small region, antero-dorsal in position, and the long, broad, medulla oblongata, roofed by the membranous tela choroidea covering the fourth ventricle.

The auditory organ is now vesicular. The olfactory placodes are slightly larger than in the previous stage and the lens has formed in the eye.

Stage F.—About 36 hours old; 40 somites (Fig. 2,A; Fig. 3,A).

The embryo is now showing the first signs of muscular movement in the tail region. The body no longer lies perfectly straight on the yolk but is twisted somewhat in the posterior region. About one sixth of the length of the body in the tail region is not attached to the yolk. A number of small red pigment spots have formed on the yolk sac. Just anterior to the head is a group of oil globules.

The brain has developed considerably since the preceding stage; the forebrain has now differentiated into a small, compact, anterior portion and behind this broader cerebrum and diencephalon. The latter has a thin roof, the tela choroidea, covering the third ventricle. At the level of the cerebrum are two cell masses, the olfactory placodes. More posteriorly the brain loses its spreading appearance and becomes rectangular with a thicker roof. The optic stalk is still hollow. As a result of the invagination of the optic vesicle, the optocoel is almost eliminated. The lens is completely free from the head ectoderm. In cross section it can be seen to be made up of a number of spirally arranged squamous nuclei surrounded by a layer of low,

columnar cells. The retina is a thick layer composed of columnar nuclei about six cells deep, all oriented towards the lens. The sclerotic coat is very thin.

Just behind the optic stalks the dorsal part of the brain begins to spread laterally and becomes thin-roofed. This area is the mid-brain consisting of the optic lobes. They spread out over the posterior part of the eye as far back as the cerebellum. The infundibulum is located in this region as a ventral and posterior evagination of the diencephalon. There is no sign of the hypophysis.

The cerebellum is thick-walled and lies immediately anterior to the larger elongate medulla oblongata which merges with the spinal cord at the level of the Cuvierian ducts. The otic vesicles appear as simple, hollow sacs ventral and lateral to the middle of the medulla. About eight sections posterior to the otic vesicles the anterior tip of the notochord could be seen. It is vacuolated for most of its length, the most posterior tip being a solid rod of cells, the condition of the entire notochord in its earliest stages.

Two aggregations on the ventral surface, the future visceral arches, can now be seen immediately posterior to the infundibulum. The heart, which is to be seen in all previous sections on the ventral surface, off center under one of the eyes, divides upon reaching the visceral arches and sends paired vessels, the aortic arches, up through this tissue.

In the muscular region of the body are two very large blood vessels lying between the gut and the notochord. They occupy the former position of the intermediate cell mass or blood anlage. The dorsal vessel is the dorsal aorta and carries blood back toward the tail. At its distal extremity it turns ventrally and anteriorly and becomes the caudal vein. At the point where the tail joins the yolk this vein splits in two. One branch, the vitello-caudal vein, empties into the yolk-sack circulation just posterior to the anus. The other vessel, which runs anteriorly under the dorsal aorta, probably joins one of the Cuvierian ducts. It could not be identified with any certainty, but may possibly be the right posterior cardinal vein. The vitelline circulation can now be seen clearly. The two Cuvierian ducts empty into the sinus venosus which passes back beneath the head to the ventricle which is still under the midbrain. Meeting the Cuvierian vessels, just anterior to the head is the vitello-caudal vein which has travelled around the yolk from the anal region of the embryo. As the embryo develops the heart migrates slowly anteriorly so that it eventually lies

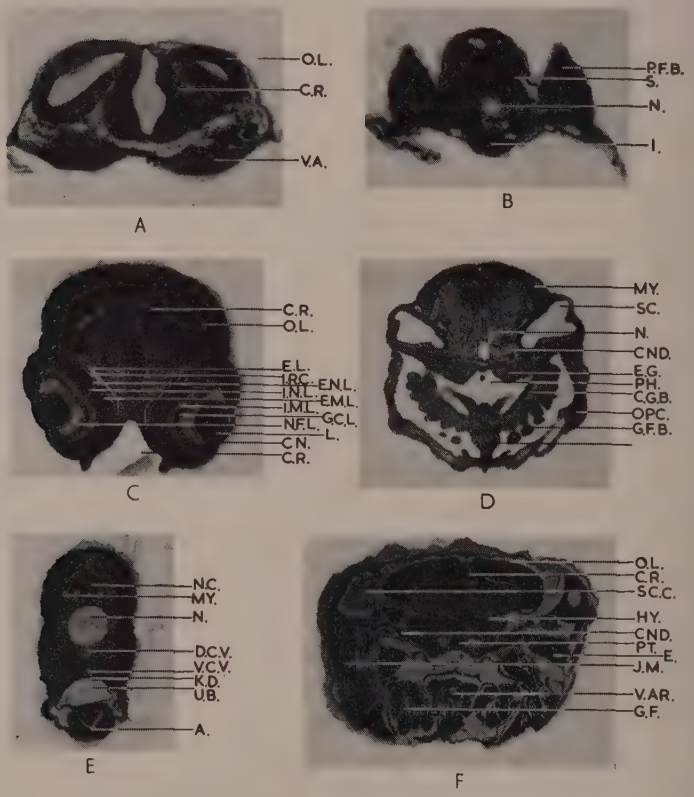

FIGURE 3. A—Section through cerebellum of 36 hour old embryo. B—Section through somite No. 1 of 48 hour old embryo. C—Section through eye of hatching stage. D—Section through posterior part of head of hatching stage. E.—Section through region of anus of hatching stage. F—Section through posterior edge of eye of 7-10 day old larva.

SYMBOLS: A.—anus, CN.—cornea, C.R.—cerebellum, CND.—chondocranium, C.G.B.—cartilagenous gill bar, D.C.V.—dorsal caudal vein, E.—eye, E.L.—epithelial layer, EML.—external molecular layer, ENL.—external nuclear layer, E.G.—enamel gland, G.F.—gill filament, G.F.B.—gill filament bud, G.C.L.—ganglion cell layer, HY.—hypothalamus, I.—intestine, I.M.L.—internal molecular layer, I.N.L.—internal nuclear layer, I.R.C.—layer of immature rods and cones, J.M.—jaw muscles, K.D.—kidney duct, L.—lens, MY.—myotome, N.—notochord, N.C.—nerve cord, N.F.L.—nerve fiber layer, O.L.—optic lobe, OPC.—operculum, PH.—pharynx, PT.—pituitary, P.F.B.—pectoral fin bud, S.—somite, SC.—sacculus, SC.C.—semi-circular canal, V.A.—visceral arch, V.C.V.—ventral caudal vein, V.AR.—ventral aorta.

on the yolk mass just in front of the head. The blood now contains colorless cells.

Stage G.—48 hours old; 44 somites (Fig. 3, B)

The embryo is now considerably twisted in its position on the yolk and movements occur quite frequently. About one quarter of the length of the body is free of attachment to the yolk at this time. Brick-red chromatophores are present on the yolk and tend to arrange themselves, as noted by Stockard (1915), beside the blood vessels.

The embryo at this stage has much in common with Stage F. There has been a certain amount of growth, but on the whole the general features are the same.

The optic stalk is reduced and optic nerves can now be seen arising on the internal surface of the retina, passing through the latter and along the path of the optic stalk to the brain. Ventral to the infundibulum is a small group of cells which will become the hypophysis.

Four pairs of visceral pouches can be seen at this stage. The pectoral fins are noticeably larger but still fleshy and pyramidal in shape.

Stage H.—72 hours old (Fig. 2, B and C)

The embryo is now definitely bent laterally, the body forming a complete circle with the tail covering the head. About half the length of the embryo is now free from the yolk mass.

The heart is no longer a straight tube but has twisted in the region of atrium and ventricle and has migrated forward so that the latter two chambers are largely anterior to the head. By the time of hatching they will be completely anterior. Sometime between Stages G and H the blood has become red in color.

Pigmentation is now more complete with stellate melanophores covering all but the most posterior part of the body. Brick red chromatophores, the only pigment cells present on the yolk sac are also to be found on the embryo along with the melanophores. Preservation in either Stockard's or Bouin's solutions maintained the melanophores but destroyed the chromatophores.

The lower jaw is now formed but the time of the opening of the mouth was not established. The liver is a well-developed outpocketing of the gut. The pectoral fins are thin folds in which the supporting rays are developing. They are now motile. In the anal region of the embryo the median fin fold and the pelvic fins have formed. The latter appear as fleshy buds near the posterior junction of the yolk sac and ventral tail musculature.

Stage I.—Hatching Stage (Fig. 2, D and E; Fig. 3, C, D and E)

Hatching begins at 96 hours and continues for a day or more. All newly hatched larvae of *H. affinis* seem to be at the same stage of physical development, with respect to the fins and yolk sac, regardless of early or late hatching.

When the embryo hatches it can swim actively. Melanophores cover most of its body and the upper quarter of the yolk mass. The eyes are only slightly pigmented. The dorsal and anal fins, which are unsupported by fin rays, are still continuous with the caudal fin, in which rays are just beginning to form.

The brain has developed a great deal. It is very large in relation to the rest of the head and is now divided up into nuclear and anuclear, or fibrous, areas. The olfactory placode extends up to and almost touches the forebrain. The eye is probably not yet functional since the optic nerve is poorly developed and visual and pigment epithelial cells are immature. A number of different retinal layers can be seen and these are identified on the basis of the work of Brett and Ali (1958) on the retina of the Pacific salmon. Starting with the most internal layer, that closest to the lens, the following were present: the nerve fibre layer, the ganglion cell layer, the internal molecular layer, the internal nuclear layer, the external molecular layer, the external nuclear layer, the layer of immature rods and cones and the pigment epithelial layer. The otic vesicle is beginning to form the sacculus and semi-circular canals. The cerebellum is still small and can be seen between the posterior parts of the two extensive optic lobes. A small mass of cells below the hypothalamus is the pituitary gland. Glandular structures in the roof of the pharynx were tentatively identified as enamel organs.

The anus, urinary bladder and its connection with the kidney ducts can be seen in Plate 1, E, as well as parts of the circulatory system. In the tail region there are two veins carrying blood anteriorly, the dorsal caudal vein just below the notochord and the ventral caudal vein above the median fin. Just anterior to the anus and urinary bladder there is a cross connection between these two vessels. The dorsal caudal vein continues as one vessel, probably the right posterior cardinal. Farther forward, in the region of the pelvic fins, the larger vitello-caudal vein branches off the ventral caudal (here known as the central caudal) vein, passes to one side of the gut, ventral to the yolk sac and so to the heart. The heart is still situated on the yolk

mass and as the latter is absorbed it moves into the body between the gills and liver.

Stage J.—Early larval stage (Fig. 2, F)

About a day after hatching the yolk sac has been completely absorbed and the young fish are feeding. During the first three or four larval days they behaved as follows: at night they ranged widely throughout their small container but during the day stayed ventral side up at the water surface. When a little older they still remained at the surface during the day, but with the dorsal side up.

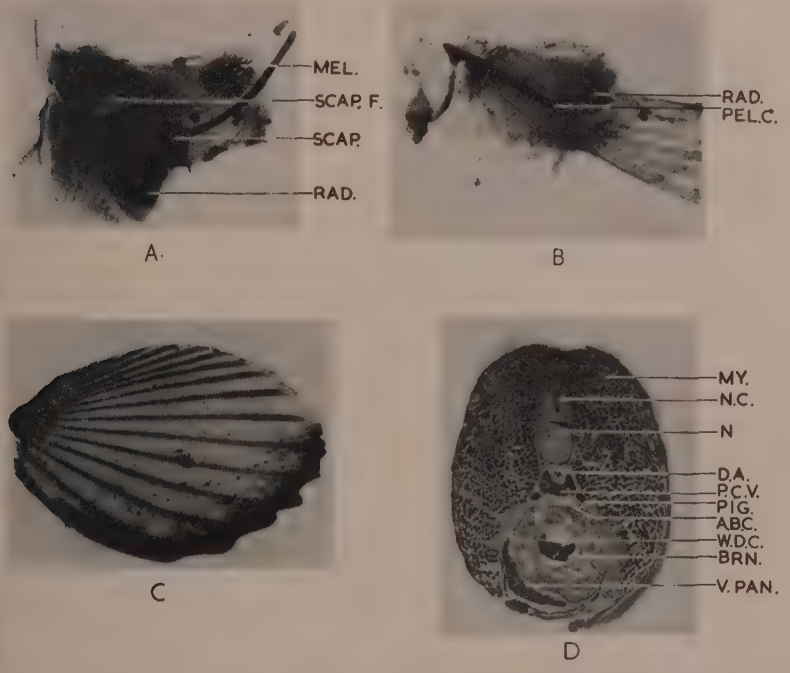

FIGURE 4. A—Pectoral girdle of 7-10 day old larva. B—Pelvic girdle of 7-10 day old larva. C—Pectoral fin of 7-10 day old larva. D—Section through mid body of 7-10 day old larva.

SYMBOLS: A.B.C.—air bladder cavity, BRN.—brine shrimp egg, D.A.—dorsal aorta, MEL.—expanded melanophore, MY,—myotome, N.—notochord, N.C.—nerve cord, PEL.C.—pelvic cartilage, R.C.V.—post cardinal vein, PIG.—pigment cell, RAD.—radial, SCAP.—scapularcoraroid, SCAP.F.—scapular foramen, V.PAN.—ventral pancreas, W.D.C.—wall of digestive canal.

All the body is densely pigmented except the fins and the most posterior portion of the tail. Living fish at this stage vary in color between deep brown and iridescent blue. The eyes are now heavily pigmented.

The pelvic and pectoral fins are somewhat larger and are supported by fairly well-defined rays. The single dorsal fin and the anal fin are also supported by rays and are no longer continuous with the caudal fin. The latter is still rounded in shape.

Stage K.—Late larval stage. (Fig. 2, G; Fig. 3, F; Fig. 4, A, B, C and D)

This stage includes all fish which survived from seven to ten days after hatching. By this time the most healthy individuals had grown to about fifteen millimeters in total length. As mentioned earlier, these fish remained at the surface during the day and fed actively upon the brine shrimp larvae provided.

The adult fish when swimming usually holds its long pectoral fins closely pressed to the sides of the body. The young fish, on the other hand, swam about with their large pectoral and pelvic fins fully expanded.

The living fish at this stage were usually a dark metallic blue on the dorsal surface and silvery on the ventral surface. In the fixed material large, stellate melanophores could be seen on the postero-dorsal half of the body, on the belly and on that part of the brain which is not as yet covered by cartilage. In the latter two sites the pigment cells were just underneath the epidermis. Similar cells occur singly on the operculum and the pectoral fin base. In addition small, finely branched melanophores occur on the distal edges of the pectoral and pelvic fins where they are so closely packed and intertwined that at first glance the edge of the fin appears to be homogeneously pigmented. There are also large, unbranched melanophores widely scattered throughout the interior of the body. They were not found within the organs but rather in spaces between them, attached to connective tissue.

The brain has changed substantially since hatching and has assumed adult shape and proportions. The nares have migrated dorsally to take up a position above the anterior edge of the eye. The olfactory organs are thickened cups of sensory cells and the olfactory stalks pass forward through two holes in the chrondocranium as paired extensions of the forebrain.

The eyes are large but in the sections available are very much distorted. Slightly posterior of center of each eye the optic nerve can be seen to pass through the retina and run medially and dorsally to the brain. Just ventral to the forebrain the two nerves cross at the optic chiasma. They pass one another with no apparent mixing of fibres, proceed up the other side of the forebrain and enter the anterior end of the optic lobes which cover the forebrain. Medially and just anterior to the optic lobes the pineal body can be seen.

The hypothalamus now lies ventral to the forebrain at the level of the posterior part of the eye. It is a bilobed structure and ends at about the same level as do the optic lobes. The pituitary gland appears as a small mass of darkly staining cells under the middle part of the hypothalamus. At the level of the pituitary gland the cerebellum appears between the two optic lobes. It spreads out laterally over the hindbrain as the optic lobes pinch off posteriorly. The cerebellum has become much larger.

The otic vesicle is now a complex organ. The semi-circular canals and other parts are loosely surrounded by head mesenchyme. No attempt was made to follow or work out in detail the configuration of these tubules. Otoliths were not seen in this or any other stage. Whether this is due to fixation or an actual lack of otoliths at this time was not determined.

Much cartilage has formed since hatching when it was confined to small amounts ventral to the hindbrain, around the otic vesicles and on the roof of the mouth. Now it is well developed in the cartilaginous skull, the mandibular and gill arches and the bases of the caudal, anal and dorsal fins. The tail shows two triangular hypurals, three smaller neural arches and three ventral haemal spines. It can now be seen that the tail is homocercal. The narrow, posterior extremity of the notochord still tilts upward and runs a short distance between the upper hypural and the last neural arch.

The pectoral and pelvic girdles have now become cartilaginous. The pelvic girdle consists of a pair of pelvic cartilages which lie separately in the body wall. Each is a long, thin rod articulating with a radial. The pectoral girdle is similar to the pelvic in that it also takes the form of a long rod which broadens at the base of the fin into a plate-like structure. The whole cartilaginous element, according to Goodrich (1930), should probably be called the scapulocoracoid, and the foramen the scapular foramen. Four radials articulate with the scapulocoracoid. Two muscles originate anteriorly and ventrally on

the girdle. One passes dorsal to the cartilage to attach on the fin while the other lies ventral to the bar and attaches to the fin from below. The two muscle masses are clearly levator and depressor in function.

The notochord is still complete but there is some indication of the beginnings of vertebrae in the form of segmentally arranged rings of dense connective tissue. Forty-six such rings were counted at this stage. They do not display a cartilage staining reaction at this time.

The alimentary canal is a tube which runs straight and unbranched from the mouth to the anus. The mouth is lined with a non-glandular epithelium as is the anterior half of the pharynx. The posterior half of the pharynx is very glandular. The visceral clefts open off the lateral ventral floor of the pharynx. Posterior to the visceral clefts, the horizontally flattened pharynx leads to the oesophagus. The latter, as it progresses posteriorly becomes smaller, rounded and less glandular and the junction of stomach and oesophagus is ringed by a powerful sphincter. The stomach and intestine are indistinguishable from one another. They form one large sac lined with glandular epithelium which might be termed a digestive canal. The posterior quarter of this sac is partially partitioned off from the rest by an internal ridge of tissue which may act as a sphincter.

The liver surrounds the lower and lateral sides of the anterior part of the stomach. A well-developed gall bladder is present. The pancreas takes the form of two lobes, one ventral to the posterior half of the digestive canal and one dorsal to the anterior half. Both parts of the pancreas are quite extensive, flattened masses of cells.

The air bladder appears as a space between the digestive canal and the dorsal kidney. The walls are very thin and pigmented. The head, or anterior part of the kidney is at the same level as the anterior tip of the notochord. The kidney extends back along the dorsal wall of the body cavity. The kidney ducts lead into the urinary bladder which is simply the swollen mesodermal junction of the ducts. The bladder opens separately behind the anus.

Discussion

The eggs of *H. affinis* develop at the surface of the sea and this would seem to indicate that they should be typical pelagic eggs. This study, however, shows that they have all the developmental features of a demersal marine teleost. In the first place the eggs are heavier than sea water and without the buoyant support of the sargassum weed would sink to the bottom.

Secondly, the zona radiata, as a tough, clear membrane with filaments which are extensions of itself, is typical of demersal eggs. The fact that the eggs are laid in masses attached to a weed is also a demersal feature.

Thirdly, vitelline circulation begins at Stage F and is characteristic of a considerable part of embryonic life. Williamson (1898) states that in demersal eggs the absorption of yolk is mainly effected by means of an elaborate vitelline blood circulation, whereas in pelagic ova, with one or two rare exceptions, no vitelline blood circulation exists.

The larva of *H. affinis* is also demersal in type. According to Shelbourne (1955) the demersal larva differs from the pelagic in three ways. In the first place the pelagic larva has a very voluminous subdermal space and the myotomes are relatively weak, whereas the body of the demersal larva is more compact, with well-developed myotomes and little subdermal space. Secondly, large dorsal median fins which extend up over the medulla oblongata are characteristic of pelagic larvae and this feature is the exception rather than the rule in demersal forms. Finally, the conspicuous rayless median fins of the pelagic larva persist well into the post-larval phase, while the median fins of the demersal larva may develop rays soon after hatching.

An examination of the cross sections of the newly hatched larva of *H. affinis* shows that it has a well-muscled body and no subdermal space. The figures of the whole larva show that the dorsal median fin extends only about half way up the body. The median fins are rayless at hatching, but about 12 hours later the rays begin to form. It seems fairly likely, therefore, that this fish originally laid its eggs on weed attached to the bottom, that is, laid truly demersal eggs, and has only secondarily adapted itself to the pelagic environment.

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NOTES ON THE WEST ATLANTIC JAWFISHES, *OPISTHOGNATHUS AURIFRONS*, *O. LONCHURUS* AND *GNATHYPOPS BERMUDEZI*[1]

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ABSTRACT

Opisthognathus aurifrons (Jordan and Thompson) is redescribed, with special emphasis on differences in color pattern and certain counts in different geographic locations. *Gnathypops bermudezi* Howell Rivero is synonymized with *O. aurifrons*. The species is recorded for the first time from the Bahamas and the Virgin Islands. Descriptive notes are given for *O. lonchurus* Jordan and Gilbert and its known distribution is extended southward from Haiti to Surinam.

INTRODUCTION AND ACKNOWLEDGMENTS

In many respects, *Opisthognathus aurifrons* (Jordan and Thompson) is very unlike nearly all of its congeners in the West Atlantic. Among these are its compressed head, delicate coloration and conformation, lanceolate caudal fin, long and slender ventral fins, long recurved canines, increased number of gill rakers, different structure and arrangement of lateral line pores on head and body and different habits. For a time we considered placing *aurifrons* in a genus separate from the other species of *Opisthognathus* in the area, and perhaps this will still be shown wisest. However, we have recently examined specimens of *Opisthognathus lonchurus* Jordan and Gilbert and this species is, in at least some of the features listed above, intermediate between the usual Atlantic *Opisthognathus* (e. g., *maxillosus, whitehursti, fasciatus,* etc.) and the extreme *aurifrons*. As a result, all species are presently retained in *Opisthognathus*. The possible relationship of the species of *Lonchopisthus* (the genus with "pungent" dorsal spines) to *lonchurus* and *aurifrons* remains to be elucidated.

A further product of this study was the realization that *Gnathypops bermudezi* Howell Rivero is a synonym of *Opisthognathus aurifrons,* a species it was not compared with at the time of its description. When only material from Florida and the Bahamas was available, this seemed

[1]Contribution 346 from The Marine Laboratory, University of Miami.

to represent two distinct species, the Florida form *aurifrons* and the Bahaman one like Howell Rivero's paratype and thus referable to *bermudezi*. This picture has become complicated by our more recent acquisition of collections from the Virgin Islands which are intermediate in all the characters we utilized to separate the Florida and Bahama material. We have now decided to treat all as a single species and to explain the maintenance of geographically localized differences by the presumed oral brooding of the eggs and the occupation of permanent burrows by adults—both helping to reduce genetic interchange.

Many persons have helped us in this study and we wish to express our thanks to them. The Academy's Bahama Shore Fish Program supported by Mr. Charles C. G. Chaplin and the University of Miami Institute of Marine Science project of Dr. C. Richard Robins in the Florida Keys and Dr. John E. Randall in the Virgin Islands supplied most of the specimens. In addition, a part of the Virgin Islands material was collected by the junior author on a trip supported by a grant from the National Science Foundation (Grant No. G-5941) and Dingell-Johnson project funds (Project No. F-2-R-2). Mr. William C. Schroeder and Mrs. Myvanwy Dick of the Museum of Comparative Zoology at Harvard lent the paratype of *Gnathypops bermudezi* Howell Rivero. Most of this study was done at the Institute of Marine Science, University of Miami and we wish to thank the officials of that institution, particularly Dr. C. Richard Robins, for the use of their facilities.

Most counts and measurements were taken in standard fashion. The lengths of pectoral and caudal fins are the lengths of the longest, median, rays. The diameter of the eye is the measurement of the eyeball. The last two rays in the dorsal and anal fins have their bases closely approximated and were counted as one ray. The counts of gill

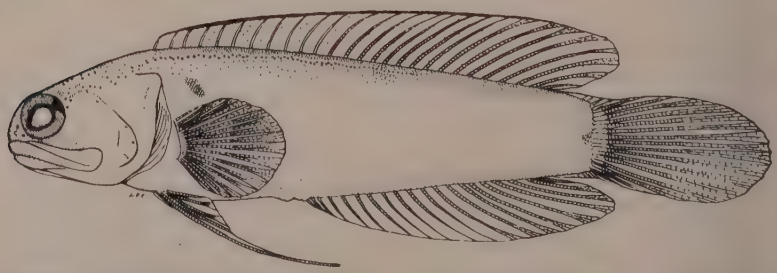

FIGURE 1. *Opisthognathus aurifrons* (Jordan and Thompson): drawn from UMML 5320, 56.1 mm standard length, by L. P. Thomas.

rakers on the lower limb of the first arch include the raker at the angle. Both the uppermost and lowermost pectoral rays are often small and difficult to see without utilizing reflected light.

Opisthognathus aurifrons (Jordan and Thompson)
Figures 1-3, Tables 1-3.

Gnathypops aurifrons Jordan and Thompson 1905, Bull. Bur. Fish., 24 for 1904: 252, fig. 4 (Type locality: coral reef at Garden Key, Tortugas, Florida. Holotype: no. 8413, Natural History Museum, Stanford University).
Opisthognathus aurifrons, Longley and Hildebrand 1941, Pap. Tortugas Lab., 34: 242, pl. 30, fig. 1 (description; habits; Tortugas).
Gnathypops bermudezi Howell Rivero 1936, Proc. Boston Soc. Nat. Hist., 41 (4): 66 (Type locality: Matanzas, Cuba. Holotype: no. 34147, Museum of Comparative Zoology, Harvard College).

Discussion.—Table 1 compares counts of dorsal, anal and pectoral rays and also the posterior extent of the lateral line of specimens from the various geographic localities. The Florida and Bahama samples are distinct in all these characters, but the Virgin Islands specimens are intermediate.

Figure 2 is a scatter diagram of lower gill rakers plotted against standard length. This is to show, first, that the number of rakers increases with growth and, second, the difference in number of rakers between Florida and Bahama specimens and the intermediacy of those from the Virgin Islands.

Table 2 presents proportions and counts of the paratype of *bermudezi* and small series of specimens from each of the three areas represented in our collections. The paratype of *bermudezi* has apparently

TABLE 1

Opisthognathus aurifrons: A COMPARISON OF FIN-RAY COUNTS AND POSTERIOR EXTENT OF THE LATERAL LINE OF SAMPLES FROM SEVERAL GEOGRAPHIC LOCATIONS.

	Branched Dorsal Rays			Branched Anal Rays				Pectoral Rays		
	15	16	17	14	15	16	18	19	20	21
V. I.	15	9	1		16	10	1	13	38	
Bahamas	1	11	6		4	14		8	24	4
Florida	13	2		1	12	2	1	20	9	
Cuba	1			1*					2	

	Lat. line back to branched dorsal ray						
	2	3	4	5	6	7	8
V. I.				2	3	4	6
Bahamas				5	9	2	
Florida	1		4	6	4		
Cuba					1		

*Abnormal

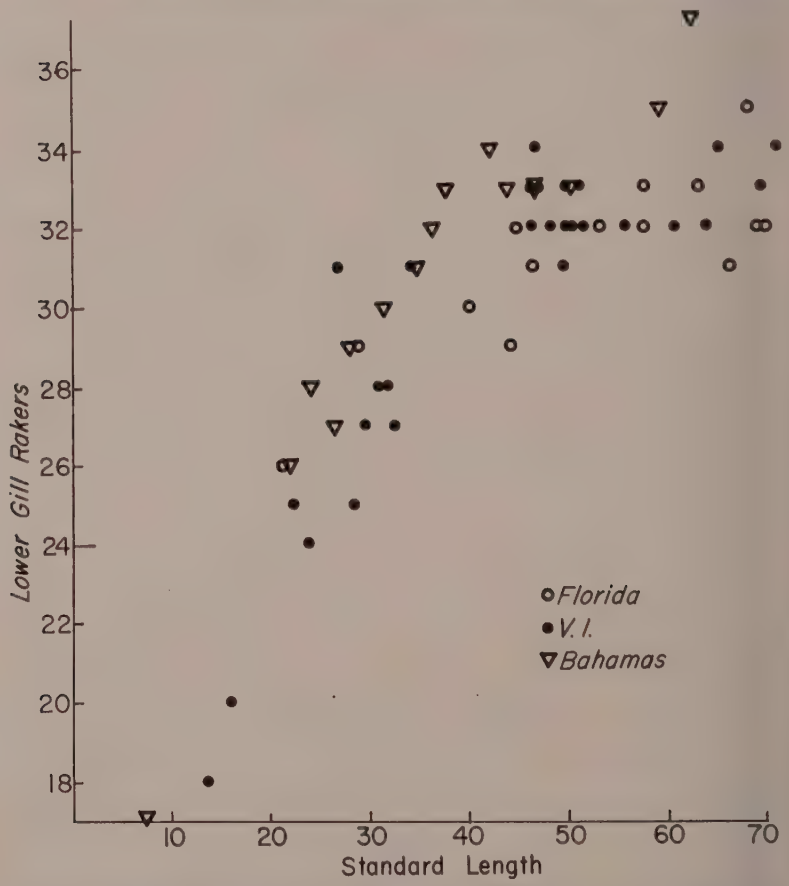

FIGURE 2. *Opisthognathus aurifrons* (Jordan and Thompson): a scatter diagram of lower gill rakers plotted against standard length, for populations from three geographic areas.

been partly dried at some point in its history and is shrunken; the proportions given for it are only approximate and should not be relied upon.

Table 3 compares samples of *aurifrons* from the several localities represented in our collections for the presence or absence of certain black markings on the head. Here again, the sample from the Virgin Islands is intermediate between those from the Bahamas and Florida

in the total amount of black pigment present. The Virgin Islands sample also differs from the others in showing much more variation.

Figure 3 illustrates several variations in pigmentation of the lower surface of the head as shown on certain specimens from the Virgin Islands.

In essence, the dentition of *aurifrons* consists of a single row of teeth along the sides of the jaws enclosing patches of smaller teeth anteriorly. The lateral teeth on the lower jaw are greatly enlarged as strongly recurved sharp canines. They are much stronger and fewer in number than those on the upper jaw. Several anterolateral teeth of the outer series on the upper jaw are usually also developed as canines, but these are not as strong as those on the lower jaw. The included patch of teeth on the lower jaw is wider than that on the upper (the latter frequently absent or consisting of but several isolated teeth), and on both jaws these patches tend to increase in numbers of teeth and rows with increased size of fish. There may be a pair of teeth, one tooth or no teeth on the vomer. In general, more of the outer row of jaw teeth are developed as canines in Florida specimens than in those from the Bahamas. However, this distinction between these two populations is once more bridged by the material from the Virgin Islands which ranges all the way between the extremes.

Coloration.—The writers have both observed a number of freshly killed specimens as well as some live material, and the following color notes are based on these.

The head and nape are pale yellow, this color often extending well onto the anterior portion of the dorsal fin. The remainder of the body, including the anal fin, the posterior half of the dorsal fin and the caudal fin, is pale grayish-blue on gross examination. A closer look, however, shows the grayish-blue color on the body of the fish a result of the combination of blue spots on each of the scales and a grayish background. A fine dark blue line borders the free edge of the dorsal fin.

The pupil of the eye is round posteriorly and prolonged into a slight lobe anteroventrally, so that it has a tear-drop shape. The significance of this shape is discussed below. A small black spot is often found on the posterodorsal edge of the eye on the long axis of the pupil. The iris is yellow distally and black proximally, the two colors separated by a blue ring which is broken by an anteroventral black spot. This

TABLE 2

Opisthognathus aurifrons AND *O. lonchurus*: MEASUREMENTS AS THOUSANDTHS OF STANDARD LENGTH AND COUNTS OF A SERIES OF SPECIMENS.

	O. aurifrons								
	Bahamas					Florida			
	ANSP 74305	UMML 7805	ANSP 78824	UMML 7805	ANSP 74305	UMML 3629	USNM 117036	UMML 5324	UMML 5324
Standard length (mm)	37.8	47.0	50.6	56.0	59.4	40.2	45.0	53.5	57.9
Snout to dorsal fin	304	300	290	289	276	308	291	280	280
Snout to anal fin	492	485	494	475	496	507	507	499	511
Longest pectoral ray	204	—	204	—	200	221	204	200	186
Length ventral fin	307	308	312	264	279	373	344	305	309
Longest caudal ray	358	332	379	353	374	373	369	350	337
Depth at origin of anal fin	217	217	219	221	188	223	227	222	219
Least depth caudal peduncle	138	140	142	148	135	147	144	142	143
Length of head	304	298	294	300	279	321	302	295	300
Diameter of eye	098	085	089	082	084	092	084	078	081
Length of upper jaw	177	179	184	182	175	182	180	174	181
Counts:									
Dorsal fin	XI,17	XI,17	XI,15	XI,16	XI,17	XI,15	XI,15	XI,15	XI,15
Anal fin	III,16	III,16	III,15	III,16	III,16	III,15	III,15	III,16	III,15
Pectoral fins	20/20	21/21	20/19	20/20	20/20	19/19	19/19	20/20	20/20
Lower gill rakers	33	33	33	—	35	30	32	32	33

TABLE 2 (Continued)

	O. aurifrons						*O. lonchurus*	
	Cuba	Virgin Islands						
	MCZ 34148	UMML 5322	UMML 5321	UMML 5323	UMML 5320	UMML 4944	ANSP 83680	UMML 3991
Standard length (mm)	62.6	46.6	49.8	51.6	56.1	64.3	88.7	91.9
Snout to dorsal fin	283	277	305	289	269	250	300	302
Snout to anal fin	501	508	488	480	520	513	585	545
Longest pectoral ray	188	180	—	—	166	162	153	160
Length ventral fin	—	317	—	289	299	—	202	220
Longest caudal ray	353	317	341	325	306	298	243	249
Depth at origin of anal fin	211	223	217	215	224	207	174	194
Least depth caudal peduncle	137	139	148	139	141	134	109	118
Length of head	297	277	307	294	280	274	338	335
Diameter of eye	078	079	076	076	073	072	101	090
Length of upper jaw	176	161	189	188	168	160	223	227
Counts:								
Dorsal fin	XI,15	XI,15	XI,16	XI,16	XI,15	XI,15	XI,12	XI,12
Anal fin	III,14[1]	III,15	III,15	III,16	III,16	III,15	III,12	III,12
Pectoral fins	20/20	19/19	19/19	20/20	19/19	20/20	19/19	19/19
Lower gill rakers	35	33	31	33	32	32	28	27

[1]Abnormal

spot and the posterodorsal one accentuate the transversely slanted aspect of the pupil.

In specimens smaller than 20 mm, the yellow color tends to be centralized in a small area on top of the head just behind the eyes. The posterior half of the body of these smaller specimens has not developed blue coloration and the color pattern of the adult is not evident. An apparently juvenile feature is a row of prominent black chromatophores extending posteriorly along the side of the body from the anterior end of the anal fin to near its posterior end.

While the pattern and colors as described above remain rather constant in specimens over 20 mm in standard length, the dark chin and head markings vary considerably and show greatest variation in the Virgin Islands sample. A narrow dark line of melanophores often extends just above the dorsal edge of the maxillary, passing down under its free end. Similarly, a dark line may extend along the posterior edges of the preopercle and opercle. The branchiostegals are sometimes edged with dusky gray. Specimens under 20 mm do not have dark lines edging the opercle and preopercle or beneath the maxillary. The most prominent head markings are two black chin spots which appear, on some specimens, at the anterior end of the isthmus (Fig. 3a). Black spots or lines may also be hidden in the valleys between the isthmus and the gill membranes (Fig. 3b). In some cases these lines are continuous with the visible chin spots, and they may extend pos-

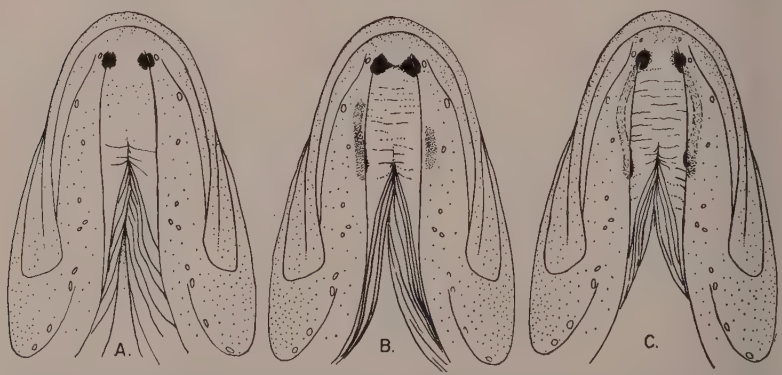

FIGURE 3. *Opisthognathus aurifrons* (Jordan and Thompson): several variations in pigmentation of the lower surface of the head of specimens from the Virgin Islands. A, UMML 5322, 46.6 mm standard length; B, UMML 5323, 51.6 mm; C, UMML 5321, 49.8 mm.

teriorly to emerge as a second pair of spots (Fig. 3c). All but one of the specimens over 20 mm taken elsewhere than in Florida has chin spots. In addition, an 18.4-mm individual from the Virgin Islands possesses the spots and one 12.0 mm long from Cay Sal Bank in the Bahamas has much scattered black pigment in the region of the spots. While no Florida specimen has black chin spots (nor were any mentioned in the original description of the species by Jordan and Thompson 1905: 252), two individuals (UMML 5324) possessed yellowish or golden markings in the region of the black spots of *aurifrons* from elsewhere.

In alcohol both juvenile and adult specimens fade to a uniform yellowish-gray color. The blue line edging the dorsal fin of adults is retained as a dark line, and the dark head markings, if present, persist.

Habits and Habitat.—*O. aurifrons* has been collected at depths ranging from 8 to 100 feet. Its commonest congeners in the region, *O. whitehursti* and *O. maxillosus,* were often found in large numbers at depths of only 2 or 3 feet, but *aurifrons* was not seen at this shallow level. Further, the burrows of *maxillosus* and *whitehursti* are most often in areas of limestone substrate which is so firm that it is frequently difficult to find a spot for a wire or rod to penetrate to force the fish to emerge. On the other hand, the burrows of *aurifrons* are in crushed coral or sand and their walls can be readily pushed aside with the hand. *O. whitehursti* and *maxillosus* are frequently found to inhabit the same rocky beds, while *aurifrons* is in colonies of its own further down.

O. maxillosus and *whitehursti* typically sit in the entrances to their burrows with just the tips of their heads protruding (in the daytime), and when frightened withdraw deeply into the burrows. In contrast, *aurifrons* normally maintains itself six or eight inches above its burrow, tail down, revolving slowly, snapping at small organisms in the water, periodically returning briefly to the burrow, and when frightened backs down into the burrow and assumes a position in the opening—not going deeply into the burrow unless badly frightened. The peculiar tear-drop shaped pupil of the eye, with its anteroventral, posterodorsal alignment, seems to be an adaption to this hovering plankton feeding existence. The anteroventral lobe of the pupil is oriented so that the fish probably has binocular vision along a plane parallel to the horizontal while maintaining a near vertical position. Such a position allows *aurifrons* a direct retreat route to its burrow with little or no

TABLE 3

Opisthognathus aurifrons: A COMPARISON OF SAMPLES FROM SEVERAL GEOGRAPHIC LOCATIONS FOR THE PRESENCE (+) OR ABSENCE (—) OF CERTAIN BLACK PIGMENT MARKINGS ON THE HEAD

	S. L.	Chin spots	Spots under gill membrane at isthmus	Curved dark line beneath maxillary	Preopercle edged with duskiness	Branchiostegals edged with duskiness
Bahamas	11.2	—	—	—	—	—
	11.6	+	—	—	—	—
	21.8	+	—	—	—	—
	24.2	+	—	—	—	—
	26.5	+	+	+	—	—
	28.0	+	+	+	—	—
	28.7	+	+	+	+	—
	29.7	+	+	+	+	—
	31.5	+	+	+	+	+
	34.9	+	+	+	+	—
	36.3	+	+	+	+	+
	37.8	+	+	+	+	+
	41.4	+	+	+	+	+
	42.3	+	+	+	+	+
	42.7	+	+	+	+	+
	47.0	+	+	+	+	+
	50.6	+	+	+	+	+
	56.0	+	+	+	+	+
	59.4	+	+	+	+	+
	62.9	+	+	+	+	+
	67.5	+	+	+	+	+
Florida	21.4 to 70.3 (15 spec.)	—	—	—	—	—
Cuba	62.6	+	+	+	+	+
Virgin Ids.	9.3 to 20.0 (18 spec.)	—	—	—	—	—
	20.8	+	—	—	—	—
	22.8	+	—	—	—	—
	24.0	+	+	—	—	—
	24.8	+	+	—	—	—
	27.6	+	—	—	—	—
	28.1	+	—	—	—	—
	29.4	+	+	—	—	—
	29.5	+	—	—	—	—
	31.5	+	+	—	—	—

TABLE 3 (continued)

S. L.	Chin spots	Spots under gill membrane at isthmus	Curved dark line beneath maxillary	Preopercle edged with duskiness	Branchiostegals edged with duskiness
31.6	+	—	—	—	—
31.8	+	+	—	—	—
35.0	+	+	—	—	—
46.6	+	—	+	+	—
46.8	+	+	—	—	—
47.3	+	—	—	—	—
47.3	+	—	—	—	—
47.5	+	—	—	—	—
48.6	+	+	—	—	—
49.1	+	+	—	—	—
49.8	+	+	—	—	—
50.0	+	—	—	—	—
50.3	+	+	+	+	—
51.0	+	—	—	—	—
51.6	+	+	—	—	—
54.8	+	—	—	—	—
56.1	+	+	—	—	—
61.1	+	+	+	—	—
64.3	+	—	+	—	—
65.1	+	+	+	+	—
65.5	+	+	+	—	—
69.7	—	+	—	—	—
71.4	+	+	+	+	+

change of body alignment and allows for feeding from the same position. Other aspects of the habits of *aurifrons* are discussed in Longley and Hildebrand (1941: 242).

Range.—The "Material examined" section which follows encompasses the known range of the species.

Material examined.—BAHAMAS: ANSP 78824 (1 specimen, 50.6 mm in standard length, illustrated), ANSP 74305 (5, 31.5-59.4, plus one now in the British Museum—Natural History) and ANSP 94307 (1, cleared and stained), sta. 232, S shore of Athol Island, July 29, 1955, J. C. Briggs, M. Bradbury, E. B. and J. E. Böhlke. ANSP 78825 (1, 44.1), sta. 238, SE corner of Silver Cay, Aug. 3, 1955, J. C. Briggs, M. Bradbury, E. B. and J. E. Böhlke. ANSP 78826 (1, 42.3), sta. 246, coral head off S shore of Athol Island, Aug. 13, 1955, J. C. Briggs, M. Bradbury, E. B. and J. E. Böhlke. ANSP 94308 (5, 21.8-34.9), sta. 510, Indian Cay, off West End, Grand Bahama Island,

July 16, 1959, R. E. Schroeder, S. Gross. UMML 7805 (3, 47.0-62.9), WAS-BWI-7, ca. 200 yards W of the SW end of Water Cay, Jumentos Group, July 8, 1959, Terry Starck and W. A. Starck, II. UMML 1175 (2, 28.8-29.7), CRR-BWI-18, S side of West Bay, New Providence Island, July 16, 1957, L. P. Thomas. ANSP 94309 (3, 11.2-67.5), sta. 520, N of the second cay SW of Elbow Cay, Double Headed Shot Cays, Cay Sal Bank, May 1, 1960, D. K. Farquhar, H. P. Brown, H. R. Roberts, J. E. Böhlke, J. M. Greeven.

CUBA: MCZ 34148 (part) (1, 62.6), Matanzas Bay, Matanzas, 1935, Pedro J. Bermudez—paratype of *Gnathypops bermudezi* Howell Rivero.

FLORIDA: UMML 5324 (2, 53.5-5-57.9), WAS-F-1, Alligator Reef, ¼ mile SE of light, Aug. 9, 1959, W. A. Starck, II. UMML 3629 (1, 40.2), CRR-F-161, Alligator Reef, ca. ½ mile S of light, Aug. 3, 1958, R. E. Schroeder, W. A. Starck, II. UMML 3468 (1, 21.4), CRR-F-158, Alligator Reef, ca. ½ mile SW of light, Sept. 14, 1958, W. A. Starck, II. USNM 117036 (11, 28.9-70.3), Tortugas, W. H. Longley.

VIRGIN ISLANDS (St. John): UMML 5320 (1, 56.1, illustrated), UMML 5322 (1, 46.6, pigment of lower jaw illustrated), and UMML 4945 (2, 65.1-69.7), V.I. sta. 11, E side Greater Lameshur Bay, Dec. 14, 1958, S. and L. P. Thomas. UMML 4944 (4, 61.1-71.4), V.I. sta. 17, E side of Greater Lameshur Bay, Dec. 22, 1958, S. and L. P. Thomas. UMML 5321 and 5323 (2, 49.8-51.6, pigment of lower jaws illustrated), UMML 7806 (40, 8.6-51.9), V.I. sta. 48, point just E of Great Salt Pond Bay, Apr. 29, 1959, J. E. Randall.

Opisthognathus lonchurus Jordan and Gilbert

Opisthognathus lonchurus Jordan and Gilbert 1882, Proc. U. S. Nat. Mus., 5: 290 (Type locality: Snapper Banks off Pensacola, Florida. Holotype: no. 29671, U. S. National Museum). Jordan and Gilbert 1882, Bull. U. S. Nat. Mus., 16: 943 (redescription of types). Longley and Hildebrand 1941, Carnegie Inst. Washington Publ. 535, 'Systematic catalogue of the fishes of Tortugas, Florida, . . .': 239 (south of Tortugas, 40-50 fms.; description; *Gnathypops mystacinus* synonymized with *lenchurus*). Fowler 1952, Mem. Soc. Cubana Hist. Nat., 21 (1): 109, pl. 26, figs. 34-35 (at or near Port-au-Prince, Haiti; description). Duarte-Bello 1959, 'Catálogo de peces cubanos', Monogr. 6, Univ. Católi. Santo Tomas de Villanueva, Lab. Biol. Mar.: 106 (listed as expected to occur in Cuba).

Opisthognathus lonchurum, Jordan and Evermann 1898, Bull. U. S. Nat. Mus., 47 (3): 2281 (description after Jordan and Gilbert 1882). Jordan, Evermann and Clark (and the earlier 'check lists' by Jordan 1885, and Jordan

and Evermann 1896) 1930, Rept. U. S. Comm. Fish for 1928, app. 10: 453 (in check-list of North and Middle American fishes).

Gnathypops mystacinus Jordan 1884, Proc. U. S. Nat. Mus., 7: 37 (Type locality: ". . . spewed up by a Red Snapper at Pensacola," Florida). Jordan 1886, Proc. U. S. Nat. Mus., 9: 229 (another specimen from "Snapper Banks," near Pensacola). Longley and Hildebrand 1941, Pap. Tortugas Lab., 34: 239 (synonymized with *Opisthognathus lonchurus*).

Gnathypops mystacina, Jordan and Evermann 1898, Bull. U. S. Nat. Mus., 47 (3): 2286 (description). Jordan, Evermann and Clark 1930, Rept. U. S. Comm. Fish. for 1928, app. 10: 453 (in check-list of North and Middle American fishes).

Opisthognathus mystacinus, Bailey et al. 1960, American Fish. Soc., Spec. Publ. 2: 42 (retained, with common name "Pensacola jawfish," as a valid North American species).

Discussion.—A single row of moderately enlarged conical teeth outlining the tooth patches on the premaxillary, on the anterior half of the maxillary, and on the dentary for more than half way back to the mouth angle; these outer teeth somewhat more elongate anteriorly than laterally. The outer series enclose narrow patches of smaller teeth on both jaws anteriorly; inner patch on upper jaw irregularly bi- or triserial anteriorly, inner patch on lower jaw a bit broader, irregularly three tooth rows across at its widest point. Five teeth on vomer, four of them forming a semicircle which encloses the fifth posteriorly. We follow Longley and Hildebrand (1941: 239) in regarding *mystacinus* a synonym of *lonchurus*.

As in *O. aurifrons*, this species has a pronounced naked area behind the pectoral fin base; this feature is not as obvious in *whitehursti, fasciatus* or *macrognathus*.

Coloration in alcohol.—Body unmarked; dorsal, anal and caudal fins dusky. Head without the distinctive markings of *O. aurifrons,* but the lips dark, particularly anteriorly.

Habitat.—Nothing known. The holotype was taken from the stomach of a "Red Snapper." The *Oregon* specimen from off Surinam was taken with an 80-ft. balloon trawl at a depth of 30-33 fms.

Range.—Off Pensacola, Florida (the holotype), Port-au-Prince, Haiti and off Surinam.

Material examined.—ANSP 83680 (1 specimen, 88.7 mm in standard length), Port-au-Prince, Haiti, 1949, A. Curtis. UMML 3991 (1, 91.9), *Oregon* sta. 2262, off the coast of Surinam, Lat. 07° 18′ N, Long. 56° 49 W, Sept. 1, 1958, M/V *Oregon*.

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TAPHROMYSIS BOWMANI, N. SP., A NEW BRACKISH WATER MYSID FROM FLORIDA

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ABSTRACT

Taphromysis bowmani, n. sp., is described and figured. Comparisons are made with *T. louisianae* Banner as well as with species of other genera. A key to the two species of *Taphromysis* is provided along with notes on distribution and ecology.

INTRODUCTION

Through the kindness of Thomas E. Bowman, Division of Marine Invertebrates, Smithsonian Institution, I recently received for study two small lots of mysids, collected by Lowell P. and Shirley Thomas, Marine Laboratory, University of Miami. These two lots contained a second species of *Taphromysis* Banner which I take pleasure in dedicating to the carcinologist who sent it to me.

Taphromysis BANNER, 1953

Banner placed his new genus in the tribe Mysini Hansen and the *Mysis*-group of Zimmer (1915). Aside from *Hemimysis*, it is the only genus in the tribe in which the male pleopod 3 has but a single ramus, the 1-segmented endopodite, articulating with a normally developed propodus (Fig. 2, 2). The presence of a strong denticle on the body of the mandible is another good generic character. Type species, by monotypy and original designation, *T. louisianae* Banner, from a freshwater roadside ditch in southern Louisiana.

Taphromysis bowmani, NEW SPECIES
Figures 1-2

Material studied.—22 specimens, comprising 16 females (5 ovigerous, 5 preadult, 6 juvenile) and 6 males (4 adult, 2 juvenile), collected at Matheson's Hammock wading beach about 5 miles south of the Marine Laboratory, Biscayne Bay, Dade County, Miami, Florida, March 30 and May 22, 1960.

Description.—Body thickset, especially the abdomen; adult male immediately recognizable by the exceptional thickness of the propodus

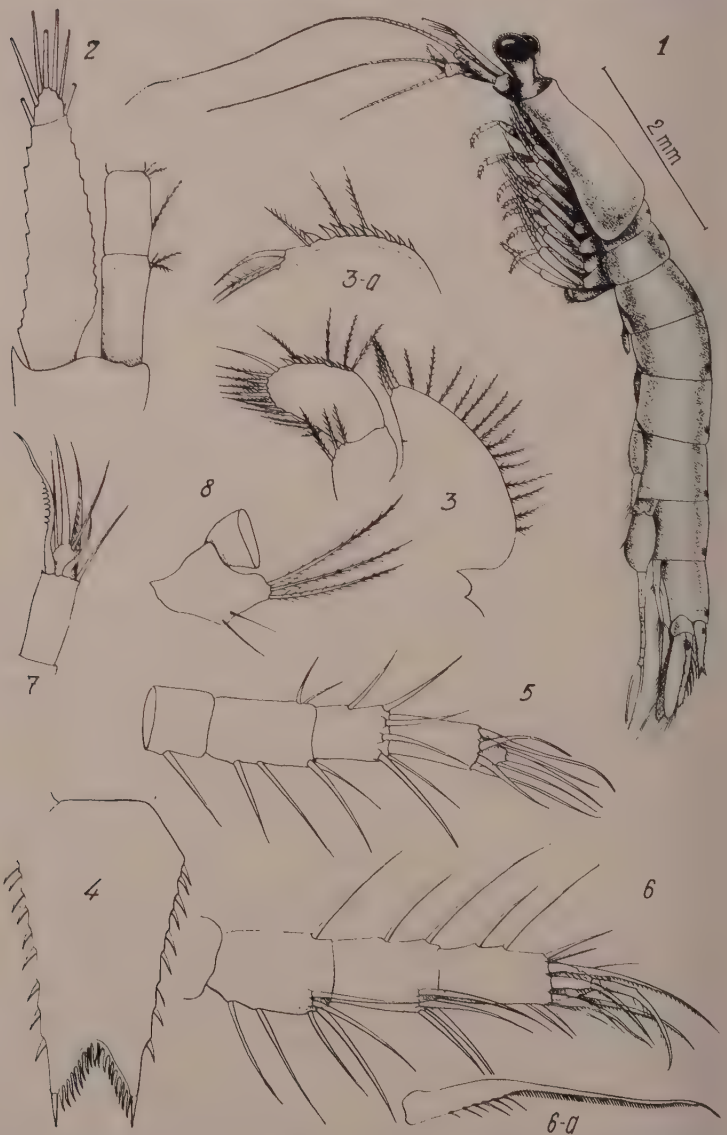

FIGURE 1. *Taphromysis bowmani*, new species. 1, Male holotype, lateral. 2, Antenna 2 of holotype. 3, Palp and exopodite of maxilla 2. 3a, distal article of palp of maxilla 2, female, showing marginal dentation. 4, Telson. 5, Pereopod 1, male. 6, perepod 1, female. 6a, paradactylous seta of pereopod 1, female. 7, distal end of pereopod 5, female. 8, anterior oostegite.

of pleopod 4 (Fig. 1, 1). Anterior margin of carapace rounded, without lateral spines *(T. louisianae* has 2); all somites smooth.

Eyes, relation between antennae 1 and 2, also labrum resmbling those of *T. louisianae.* Process masculinus of antenna 1 slightly different, relatively broader (Fig. 2, 6). Scale of antenna 2 of the type occurring in *Hemimysis lamornae* or *Antromysis anophelinae* Tattersall (1951), with setae along both margins; apical article well developed, 1/9 the length of the scale, bearing 5 setae (apical article 1/20 the length of the scale in *T. louisianae).* Flagella of antennae 1 and 2 much shorter than in *T. louisianae,* not reaching pleonite 5 (male) or scarcely reaching beyond carapace (female).

Body of mandible (Fig. 2, 7) with denticle typical for genus, palp short, molar process well-developed. Mandibular denticle, lateral in position, lies posterior to external denticle of propodus of antenna 2, the 2 denticles being easily seen in lateral view without dissection.

Distal article of palp of maxilla 2 more or less elongate, armed with 8-10 denticles, much as in *Diamysis* (Bacescu, 1940), the denticles twice as long as those of *T. louisianae,* being 1/6-1/8 the maximum width of the articles (scarcely 1/16 in *T. louisianae).*

Pereopods slightly more robust in female, structure more or less uniform in both sexes. Exopodites long, 8-segmented; tarsi all 4-segmented, becoming very little longer in posterior pereopods (Fig. 1, 5-6). Seta at apex of dactyl smooth, paradactylous setae (at apex of penultimate article, surrounding dactyl) longer, those of pereopods 4 and 5 strongly dentate (Fig. 1, 6). First article (proximal) of tarsus subequal to third, longer than second article (in *T. louisianae* first article is longer than two following articles combined).

Penis lobes of male (Fig. 2, 8) very prominent, with bicorn posterior apophysis and several elastic setae with enlarged tips around the orifice.

Female with 3 pairs of oostegites; anterior pair very small, 1/6 the size of the second and about 1/12 the size of the third pair, with only 3 plumose setae (Fig. 1, 8). Marsupium of ovigerous females with 7-10 eggs.

Pleopods of female and first 2 pairs of male reduced to 1-segmented ramus (Fig. 2, 1). Pleopod 3 of male with strongly developed basal segment, finely serrate medially, nearly unarmed, followed by a single branch, the endopodite (Fig. 2, 2), very similar to that of *Hemimysis lamornae,* but with much shorter pseudobranchial process. Male

pleopod 4 strongly developed, sometimes extending beyond the ends of the uropods. Protopodus 2-segmented (Fig. 2, 3), exceptionally thick, width only slightly greater than vertical diameter, in lateral view vertical diameter nearly half that of corresponding pleonite. In males not yet having all secondary sex characters (setae on process masculinus, etc.) in which pleopod 4 does not extend beyond level of statocyst, protopodus is of flattened form usually found in mysids. Endopodite short, 1-segmented, not longer than proximal article of exopodite, with weak pseudobranchial process (Fig. 2, 4). Exopodite distinctly 6-segmented, more or less of *Mysis* type (Zimmer, 1915, Fig. 5) ending in pincer. Penultimate article bearing long spine only very slightly curved toward terminal article. Medial margin of terminal article undulate, minutely doubly serrate in distal part; distal half of subterminal seta with more than 20 rows of 3-7 fine spinules, ending in 2 strong points, the outer one shorter.

Banner's description of the subterminal and terminal setae of the male pleopod 4 of *T. louisianae* is not complete in all details. Dr. Bowman has examined one of Banner's paratypes and reports that the subterminal seta has an undulate medial margin, and the lateral margin bears distally two rows of minute serrations. The margins of the terminal seta bear minute spines distally, forming more or less complete diagonal rows; the apex ends acutely, more so than in Banner's drawing (1953, Fig. 2, i), in contrast to the divided tip in *T. bowmani*.

The endopodite of pleopod 4 is 2-segmented, as shown by Banner; the suture is indistinct and difficult to make out. The pseudobranchial process (Banner's "exite") is nearly twice as long as wide, and bears 7 setae, 3 of which are terminal, 3 lateral, and 1 medial.

Male pleopod 5 (Fig. 2, 5) composed of 1-segmented plate as long as terminal pleonite, bearing very long terminal setae which reach beyond distal end of telson. Near the middle a tuft of setae is borne on the inner margin and a single seta on the outer margin; the insertions of these setae at times may suggest a false articulation.

Banner shows pleopod 5 of *T. louisianae* as distinctly 2-segmented, with setae limited to distal part of second article. Pleopod 5 of a paratype examined by Dr. Bowman differs markedly from Banner's description. In addition to the distal setae, it bears on the inner margin a tuft of setae at the point where the pleopod narrows and 4 single setae distal to the tuft; on the outer margin just proximal to the level of the tuft are 2 single setae. Although a faint diagonal line in the

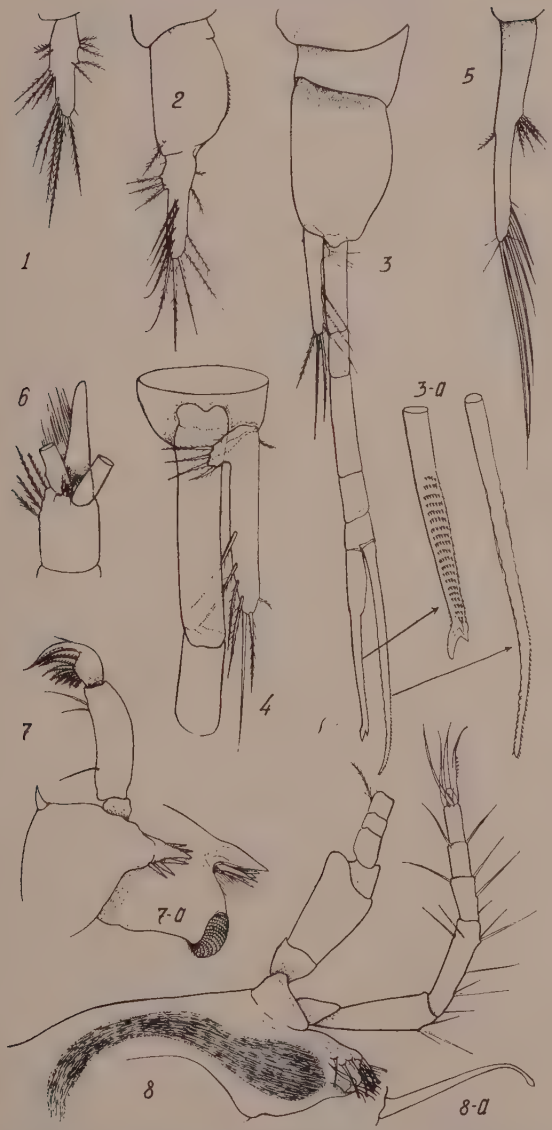

FIGURE 2. *Taphromysis bowmani,* new species, male. 1, pleopod 2. 2, pleopod 3. 3, pleopod 4. 3a, distal half of pincer of pleopod 4. 4, endopodite and first article of exopodite of pleopod 4, seen from above. 5, pleopod 5. 6, distal article of peduncle of antenna 1, with process masculinus. 7, mandible and its palp. 7a, distal part of mandible, in profile. 8, Penis and pereopod 5. 8a, One of the setae surrounding male orifice.

cuticle can be made out just distal to the tuft, it can scarcely be considered a complete suture, and pleopod 5 is, therefore, as in *T. bowmani,* 1-segmented.

Telson (Fig. 1, 4) half as long as exopodite of uropod and scarcely as long as pleonite on which it is inserted, closely resembling that of *Paramysis kroyeri* (Bacescu, 1940, Fig. 53, 93E: 636). Margins nearly straight, armed with about 8 (male) to 10 (female) equal spines; sinus subtriangular with 15 (male) to 20 (female) pointed lamina. The telson of *T. louisianae* resembles rather that of *Diamysis* (Bacescu, 1940, Fig. 20), having a broader sinus and nearly twice as many laminae.

Uropods like those of *T. louisianae;* endopodite with single spine medial and distal to statocyst. Although Banner states that the endopodite of *T. louisianae* has no spines near the statocyst, examination of a male paratype by Dr. Bowman showed that it also bears single spine near the statocyst.

Length.—Largest male, 8.17 mm; largest ovigerous female, 9 mm.

Types.—Deposited in the United States National Museum: Holotype male, USNM 106240, and 6 paratypes. Deposited in the "Grigore Antipa" Museum of Natural History, Bucharest, Rumania: Allotype female, No. 39, and 7 paratypes (2 ovigerous females, 3 preadult females, 1 adult male, and 1 juvenile male), No. 40.

Discussion.—The two species of *Taphromysis* may be distinguished by the following key:

1 (2) Margins of telson slightly concave (owing to divergence of terminal lobes), armed with 10-12 spines; sinus with more than 35 lamina. Propodus of male pleopod 4 not swollen, more or less flattened, in lateral view about 4.5 times as long as vertical diameter; subterminal seta of exopodite reaching beyond terminal seta by about 1/3 its length; terminal seta with acute apex. First article (proximal) of tarsus of pereopods as long as 2 following articles combined. Anterior margin of carapace with a pair of lateral spines.
T. louisianae Banner, 1953

2 (1) Margins of telson nearly straight, armed with 8-10 spines; sinus with 15-22 laminae. Propodus of male pleopod 4 swollen, nearly cylindrical, vertical diameter only slightly less than width, length about 3 times vertical diameter; subterminal seta of exopodite reaching only slightly beyond terminal seta; terminal seta bifid at tip. First article of tarsus of pereopods subequal to third. Anterior margin of carapace without lateral spines. ..... *T. bowmani,* n. sp.

Distribution.—Upon being informed that the mysid collected by Mr. Thomas represented a new species of *Taphromysis*, Dr. Bowman examined 6 specimens of *Taphromysis* in the U. S. National Museum collected in the Wakulla River, Wakulla County, Florida, by Marvin Wass in April, 1953. These specimens agree in all details with the Biscayne Bay material and are undoubtedly *T. bowmani*. According to Wass, they were collected from fresh water. Dr. Bowman also examined 3 specimens of *Taphromysis* collected in Bayou Southerland, on the west coast of Florida near Tarpon Springs, Hillsboro County, collected by Keith D. Woodburn in June, 1958. These specimens, also unquestionably *T. bowmani*, were taken in company with the shrimp, *Palaemonetes intermedius* Holthuis, a species characteristic of marine and brackish water, but not found in fresh water.

Evidently *T. bowmani* occurs along the entire west coast of Florida and at least as far north as Biscayne Bay on the east coast.

T. louisianae has been reported only from the type locality, a roadside ditch at Gueydan, Vermilion Parish, Louisiana. The U. S. National Museum has recently received specimens from Dr. Alfred E. Smalley, Tulane University, collected from a ditch along a marsh near Grand Lake, Calcasieu Parish, Louisiana, about 35 miles west of the type locality.

Ecology.—Information concerning the ecology of *T. bowmani* has been kindly provided by Mr. Lowell P. Thomas. The mysid was collected in shallow (1-6 inches) tide pools left on the broad sand flats of the beach at low tide. The beach, bordered by a mangrove swamp, is of fine quartz sand, with sparse patches of *Thalassia* and *Diplanthera* growing on it. The density of the *Taphromysis* population was about 10 individuals per square foot (about 90 per square meter). The salinity was not taken when the specimens were captured, but when placed in fresh water in the laboratory the mysids showed no signs of discomfort and survived all day. *Taphromysis* has remained in the Matheson's Hammock locality through January, 1961 (the date of submission of this manuscript). Four salinity readings, one each month beginning in October, reveals salinity range from 13.3 to 26.0‰. Judging from its distribution, *T. bowmani* is characteristic of brackish water, but may also occur in fresh water.

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A REDESCRIPTION OF THE PALAEMONID SHRIMP, *LEANDER PAULENSIS* ORTMANN, BASED ON MATERIAL FROM FLORIDA[1]

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Introduction and Acknowledgments

While working with the crustaceans collected during an ecology study of northern Florida Bay estuaries being carried out by The Marine Laboratory, the author discovered an unusual palaemonid shrimp of the genus *Leander*. At first the author believed that the shrimp represented an undescribed species. However, Dr. L. B. Holthuis, Rijksmuseum van Natuurlijke Historie, Leiden, examined some of the material and pointed out that it probably represented *Leander paulensis* Ortmann, a species that Holthuis (1952) had synonymized with *L. tenuicornis* (Say, 1818). Holthuis, who studied the extensive collections of *Leander* in the U. S. National Museum, found no good morphological criteria for separating the two species. A few morphological differences were found by the author in local material; a major difference lies in the color pattern of living material.

The author would like to thank Dr. L. B. Holthuis for his comments on the problem and for pointing out the possible identity of the material; Dr. Fenner A. Chace, Jr., Curator, Division of Marine Invertebrates, U. S. National Museum, for examining the material and for helpful comments on the manuscript; and Dr. Gilbert L. Voss, Curator of Marine Invertebrates, The Marine Laboratory, University of Miami, who worked with the author in framing the description and preparing the illustrations.

The study of the estuaries of northern Florida Bay was carried out by Durbin Tabb and his coworkers from The Marine Laboratory with the support of the Florida State Board of Conservation.

The material of *L. paulensis* and *L. tenuicornis* discussed below has been deposited in the Marine Museum of The Marine Laboratory, University of Miami (UMML) and the U. S. National Museum (USNM).

A portion of the material of *L. tenuicornis* from Biscayne Bay was collected by investigators studying the ecology of turtle grass (*Thalassia testudinum* König) communities supported by the National Science Foundation under Grant No. G-14521.

[1]Contribution 347 from The Marine Laboratory, University of Miami.

Leander paulensis Ortmann, 1897 (?)
Figures 1 and 2

Leander paulensis Ortmann, 1897: 192, pl. 1, fig. 14 [Sao Paulo, Brazil]; Ihering, 1897: 422; Kemp, 1925: 292.

non *Leander paulensis*, Moreira, 1901: 11 [=*Palaemon northropi* (Rankin)].

Palaemon paulensis, Rathbun, 1902: 125 [Punta Rassa and Marco, Florida; Mayagüez, Puerto Rico]; Luederwalt, 1919: 420; Schmitt, 1924: 72 [Curaçao]; Luederwalt, 1929: 53; Schmitt, 1935: 160 [discussion and synonymy; see also discussion under *L. tenuicornis*, pp. 161-162].

Leander tenuicornis, Holthuis, 1952: 155 [part, reference to *L. paulensis* only; non *Leander tenuicornis* (Say)].

Material Examined

1 ♂, 1 ♀; Joe Kemp Channel, Florida Bay; in trawl; March 15, 1958. USNM.

1 ♂, 1 ovigerous ♀; Buttonwood (Flamingo) Canal at Coot Bay; night light; Oct. 13, 1958. UMML 32.1456.

1 ovigerous ♀; Conchie Channel, Florida Bay; in trawl; Oct. 16, 1958. UMML 32.1448.

1 ♂, 1 ♀; Joe Kemp Channel, Florida Bay; in trawl; Nov. 11, 1958. UMML 32.1454.

2 ♂ ♂; Sandy Key Basin, Folrida Bay; in trawl; Jan. 13, 1959. UMML 32.1451.

1 ovigerous ♀; Buttonwood (Flamingo) Canal at Coot Bay; night light; Feb. 9, 1959. UMML 32.1453.

2 ♀ ♀, 1 ovigerous; Coot Bay; in trawl; Feb. 12, 1959. UMML 32.1450.

1 ♀; Oyster Bay (western Whitewater Bay); in trawl; Feb. 12, 1959. UMML 32.1452.

3 ♂ ♂, 1 ovigerous ♀; Florida Bay, off Slagle Ditch, East Cape Sable; in trawl; March 10, 1959. UMML 32.1455.

1 ♂; Florida Bay, off East Cape Sable; in trawl; March 10, 1959. UMML 32.1449.

1 ovigerous ♀; Conchie Channel, Florida Bay; in trawl; March 10, 1959. USNM.

1 ♂; Sandy Key Basin, Florida Bay; in trawl; March 10, 1959. USNM.

8 ♂ ♂, 1 ♀; Sandy Key Basin, Florida Bay; in trawl; March 11, 1959. UMML 32.1457.

6 ♀ ♀; Sandy Key Basin, Florida Bay; in trawl; March 11, 1959. USNM.

1 ♂; Buttonwood (Flamingo) Canal at Coot Bay; night light; April 13, 1959. USNM.

5 ♂ ♂, 2 ovigerous ♀ ♀; Joe Kemp Channel, Florida Bay; in trawl; April 15, 1959. USNM.

1 ♂, 2 ovigerous ♀ ♀; Whitewater Bay; in trawl; April 16, 1959. USNM.

5 ♂ ♂, 4 ovigerous ♀ ♀; Sandy Key Basin, Florida Bay; in trawl; April 16, 1959. USNM.

Description. The *rostrum* is of medium length, rather broad, and curved upwards. It extends to just beyond the end of the scaphocerite.

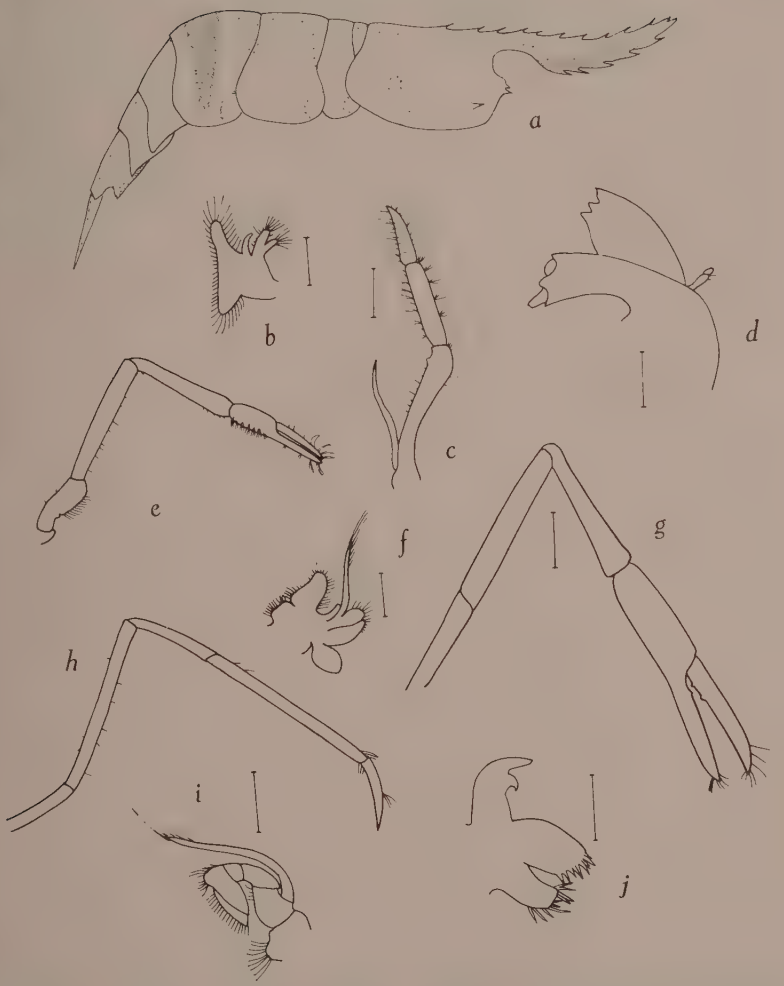

FIGURE 1. *Leander paulensis* Ortmann. a, outline of body of mature female, carapace length 4.5 mm, to show color pattern; light stippling indicates gray, dark stippling maroon; b, maxilla; c, third maxilliped; d, mandible; e, first pereiopod; f, first maxilliped; g, second pereiopod; h, fifth pereiopod; i, second maxilliped; j, maxillule. d, j, scale = 0.5 mm; b, c, f, g, i, scale = 1.0 mm; e, g, h to same scale.

There are three teeth posterior to the orbit, of which the proximal one is well posterior and separated from the second. The third tooth is nearly or directly above the orbit. The rostral formula is $\frac{3+8\text{-}11}{5\text{-}7}$, usually $\frac{3+9}{6}$.

The *carapace* is smooth. Both an antennal spine and a branchiostegal spine are present. The antennal spine is strong but slender and sharp, and placed below the round lower angle of the orbit. The branchiostegal spine is equal to the antennal spine, but is placed back from the margin, the tooth not reaching the anterior margin. There is no branchiostegal groove.

The *abdomen* is smooth. The pleura of the first three segments are rounded, those of the fourth subacute, and those of the fifth are acute. The pleuron of the fourth segment ends in a blunt, rounded angle with or without a minute spine; the pleuron of the fifth ends in a sharp angle with a minute spine visible under magnification. The sixth abdominal segment is about 1.5 times as long as the fifth. The telson is a little longer than the sixth somite and is elongate triangular in shape with two pairs of small, stout dorsal spines, one pair about midway of the telson, the other about three-fourths. The posterior margin bears two pairs of spines, an outer short pair and an inner long pair which far overreach the median point of the posterior margin which is itself long and slender. There are two feathered median setae.

The eyes are well developed, with dark brown pigment and a transverse band of lighter brown. There is a definite ocellus.

The basal segment of the antennular peduncle is broad, rectangular. The stylocerite is slender and pointed, reaching to the middle of the basal segment. The outer margin of the basal segment is nearly straight and terminates in a sharp anterolateral spine which may reach nearly to the middle of the second segment of the peduncle. The anterior margin of the basal segment is convex and may extend past the apex of the anterolateral spine. The third segment of the peduncle is longer than the second but is a little more slender. The upper antennular flagellum has the two rami fused for 6-8 joints, the free part of the shorter ramus consists of 15-20 joints. The free part is about four times longer than the fused part.

The *scaphocerite* is about four times as long as broad, the outer margin straight or slightly concave. The final tooth is strong and directed straight ahead, and may extend past the end of the lamella.

The end of the lamella is obliquely truncate, narrow, with the anterointernal angle sharp, slightly acute.

The *mouthparts* are typical of the genus. The number of segments on the mandibular palp is variable, either two or three. If two-jointed, the terminal joint is minute; if three, the joints are more or less subequal. All the mouthparts are illustrated.

The first *pereiopod* extends to about the distal fifth of the scaphocerite. The fingers are as long as, or a little longer, than the palm. In young specimens the carpus is shorter than the chela, while in older specimens it is equal to or a little longer than the chela. The merus is a little longer than the carpus. The second pereiopod reaches beyond the scaphocerite which terminates in the middle of the palm. The fingers are equal in length to the palm. The cutting edge of the dactylus bears two small teeth proximally. The cutting edge of the fixed finger has a single tooth which meets between the two teeth of the dactylus. The carpus is about two-thirds as long as the chela, but only about seven-eighths of the length of the merus. The ischium is about two-thirds the length of the merus.

The third, fourth, and fifth *pereiopods* are slender and are similar in shape. The fifth pereiopod reaches beyond the end of the scaphocerite. The dactylus is about one-third as long as the propodus, and the carpus half as long as the latter. The ischium is equal in length to the propodus.

The pleopods and uropods are normal in shape.

There is an *appendix interna* on the first pleopod of the male and an appendix masculina and interna on the second pleopod. There were no observed secondary sexual differences. The egg diameter is 0.5 mm.

Color. L. paulensis: In life, most specimens, including juveniles, males, and non-ovigerous females, are transparent, with a few lines of maroon pigment on the sides of the carapace. Ovigerous females exhibit a very different and very striking color pattern. The background color may range from transparent to dark gray. There is a streak of gray along the dorsal surface of the body that extends from the apex of the rostrum to the tip of the telson; this gray streak is interrupted only at the third abdominal segment. From this gray streak, between the first and second and second and third abdominal segments, there extends a triangular band of gray that reaches ventrally along the abdominal pleura. The lower margin of the rostrum is maroon, as is the eyestalk. There are 3-4 radiating maroon lines on the posterolateral half of the carapace. The anterolateral angles of the first, second, and third

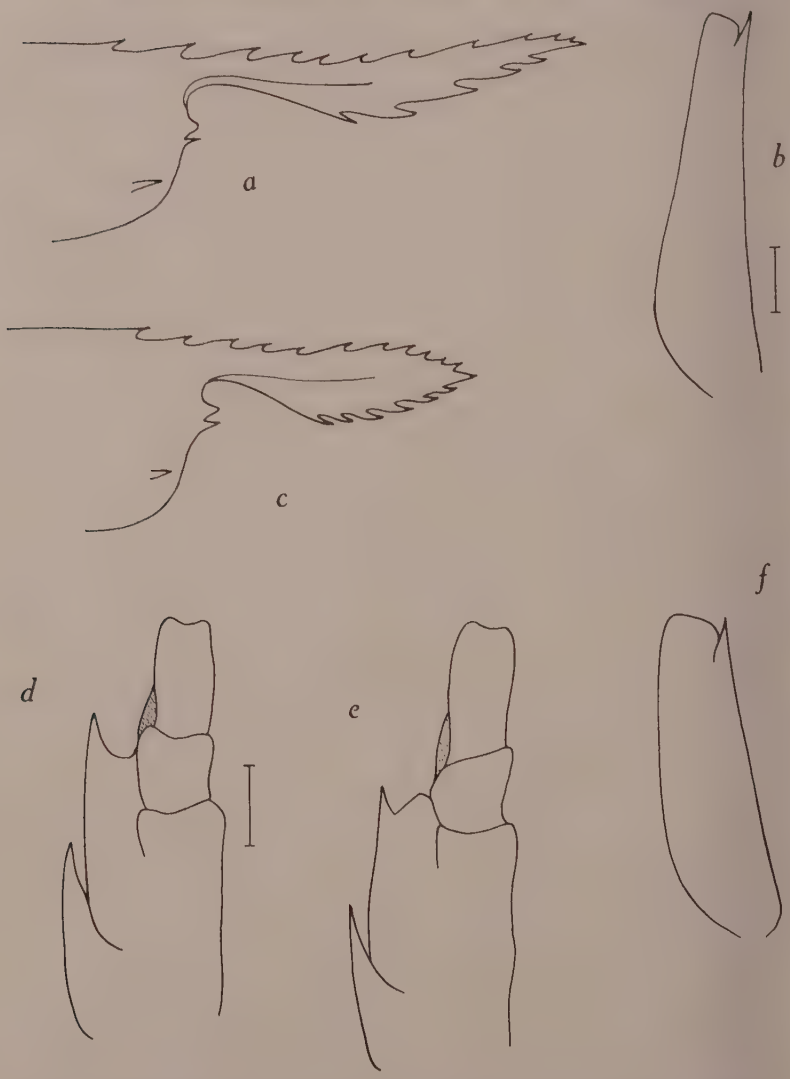

FIGURE 2. *Leander paulensis* Ortmann. a, rostrum of mature female, carapace, length 4.5 mm; b, antennal scale; d, antennular peduncle. *Leander tenuicornis* (Say). c, rostrum of adult female, carapace length 6.0 mm; e, antennular peduncle; f, antennal scale, d, e, scale = 0.5 mm; b, f, scale = 1.0 mm.

abdominal pleura have a circular patch of gray, outlined posteriorly with maroon. There is a prominent transverse band of maroon across the third abdominal somite. The fifth and sixth abdominal segments are lined ventrally with maroon, and the posterior margin of the sixth segment is gray-white. The outer uropod has longitudinal bands of maroon and cream, while the inner uropod is maroon. The scaphocerite is outlined in maroon, and the antennules and antennae are banded with maroon and cream. The pereiopods are banded with maroon, clear, and gold. The eggs are green.

The dark background of ovigerous females fades when they are placed in clear water, but the large, maroon abdominal band remains visible.

In alcohol, all specimens fade to an even cream color. A few show traces of pink on the dorsal surface of the carapace and along the rostrum, while others may have a line of red chromatophores along the rostrum.

Color. L. tenuicornis: Young specimens of both sexes have a light straw-colored background with brown or orange brown chromatophores scattered over the body in no definite pattern; the overall color is a light brown.

Older males have the last two abdominal somites and telson colored with a slightly darker brown than the preceeding somites. Some scattered white spots may be visible. Ocelli may be present on the pleura of the first and third abdominal somites; usually ocelli are lacking in the male.

Females in which the rostrum has begun to assume the adult shape still have the dorsal surface of the anterior part of the body light brown. The rostrum is darker brown, and a lateral brown streak extends from the scaphocerite to the last two abdominal somites which are also dark brown. The pleura of the first four abdominal somites may be white immediately beneath the dark stripe, or dark ocelli, ringed with a clear circle and a darker brown circle, may be present on the pleura of the first and third abdominal somites. The bases of the walking legs are brown. The palms of the second pereiopods are brown. All of the walking legs have scattered brown and white chromatophores on all surfaces.

Mature females are mottled gray and brown with the color pattern variable. The anterior part of the body is predominantly light gray with scattered brown markings. The posterior part of the body is dark brown, almost black in some specimens. The chelipeds and walking

legs are banded with white, clear and brown, in a variable pattern; the brown markings of the legs vary from light brown to almost black. The pleura of the first and third abdominal somites usually have dark ocelli, ringed with a clear or pale brown circle.

Discussion

The series of *Leander* collected in Florida Bay represent a species distinct from the well-known *Leander tenuicornis;* the characters used to separate the species are listed below. The Florida Bay material is tentatively identified as *L. paulensis* Ortmann, a species originally described from Brazil and subsequently reported from Florida and several localities in the Caribbean. As Holthuis (1952) pointed out, the characters used in the past to separate *L. paulensis* and *L. tenuicornis* are not diagnostic; these characters include the rostral dentition and the relative length and shape of the propodus and dactylus of the second pereiopod.

Unfortunately, Ortmann's description is based primarily on the characters of the claw and the rostrum. Thus, there is no way of determing whether or not the Florida Bay material (as well as the specimens recorded in the literature) really belong to Ortmann's species or whether they are distinct from *L. paulensis* as well as *L. tenuicornis*. Comparison of the Florida material with Ortmann's types (if extant) or with Brazilian material would be most desirable; no specimens from Brazil could be located at this time. In my opinion, it is better to assign the material tentatively to *L. paulensis* rather than to introduce a new name into the literature.

The available series of *L. paulensis* was closely compared with littoral material of *L. tenuicornis* from Virginia Key, Miami, Florida (UMML). The results of the comparison are summarized in Table 1. The ratios emphasize the differences in rostral shape, scaphocerite shape, and depth of body (particularly in the female) in two species.

Leander paulensis differs from *L. tenuicornis* as follows:

1. Males and females of *L. paulensis* exhibit no sexual dimorphism with respect to rostral shape. In *L. tenuicornis* the rostrum of the mature female differs markedly from that of the mature male; the blade of the rostrum is very deep in the mature female.

2. The anterior margin of the basal antennular segment is convex in *L. paulensis;* it is concave or straight in *L. tenuicornis*.

3. The stylocerite is short in *L. paulensis*, barely reaching to the

middle of the basal antennular segment; in *L. tenuicornis* the stylocerite may reach to the distal third of the basal antennular segment.

4. The scaphocerite is slender in both sexes of *L. paulensis;* it is slender in males of *L. tenuicornis,* but in females it is broader and tapers less rapidly to the apex.

5. In *L. paulensis* the propodus and dactylus of the second pereiopod are both armed with minute teeth; in *L. tenuicornis* the dactylus of the second pereiopod may be armed with a single, minute proximal tooth, although both dactylus and propodus are usually unarmed.

6. A distinctive color pattern is found in the living material of each species. The basic colors of *L. paulensis* are gray and maroon, and mature females have a prominent maroon band on the abdomen. The basic color of *L. tenuicornis* is brown in varying shades. The mature females of both species may have ocelli on the pleura of the first and third abdominal somites.

The rostra of male and female *L. tenuicornis* and the antennular peduncle and scaphocerites of both species are illustrated in figure 2.

L. paulensis differs from all other species in the genus in having

TABLE 1

BODY PROPORTIONS OF FLORIDA MATERIAL OF *Leander paulensis* ORTMANN AND *Leander tenuicornis* (SAY).

		L. paulensis			*L. tenuicornis*		
	sex	n	range	avg.	n	range	avg.
Rostrum length	♂ ♂	15	1.34-1.82	1.58	8	1.31-1.62	1.49
Carapace length	♀ ♀	8	1.25-1.44	1.33	13	0.98-1.36	1.18
	total	23	1.25-1.82	1.49	21	0.98-1.62	1.28
Carapace length	♂ ♂	16	2.91-3.66	3.21	9	3.20-4.22	3.70
Rostrum depth	♀ ♀	9	2.95-3.37	3.19	13	2.36-3.29	2.92
	total	25	2.91-3.66	3.21	22	2.36-4.22	3.24
Carapace length	♂ ♂	16	1.12-1.36	1.23	9	1.13-1.27	1.18
Carapace depth	♀ ♀	9	1.15-1.28	1.21	12	0.97-1.12	1.09
	total	25	1.12-1.36	1.21	21	0.97-1.27	1.12
Scaphocerite length	♂ ♂	16	3.37-5.00	4.25	9	4.00-4.41	3.73
Scaphocerite width	♀ ♀	9	3.58-4.50	3.91	13	2.50-3.84	3.16
	total	25	3.37-5.00	4.13	22	2.50-4.41	3.39
Carapace length	♂ ♂	15	1.04-1.34	1.13	9	1.10-1.31	1.17
Depth of second abdominal somite	♀ ♀	9	0.99-1.28	1.15	13	0.88-1.21	1.03
	total	24	0.99-1.34	1.14	22	0.88-1.31	1.08
Size range	♂ ♂		3.2-5.2 mm			3.2-4.4 mm	
Carapace length	♀ ♀		3.6-5.9 mm			4.2-6.6 mm	

both the propodus and dactylus of the second pereiopod armed.

The variability of the mandibular palp in the available material is somewhat surprising, and may indicate that this character is not as reliable a generic character as the presence or absence of the appendix interna on the first pleopod of the male.

L. paulensis is the second species of the genus known from the western Atlantic. *L. tenuicornis,* the other western Atlantic species, is a circumtropic (except East Pacific) species usually found near shore or in floating weed (*Sargassum sp.*) (Holthuis, 1950). Two other species are known, *L. kempi* Holthuis, 1950, a littoral species from the Malay Archipelago, and *L. urocaridella* Holthuis, 1950, also a littoral species known from India to the Malay Archipelago.

L. paulensis seems to be somewhat intermediate between *L. tenuicornis* and *L. kempi.* In *L. paulensis,* the pleuron of the fourth abdominal somite is bluntly rounded and may or may not be armed posteriorly with a small spine, while the pleuron of the fifth somite ends in a sharp angle and is spined posteriorly. In *L. tenuicornis,* the pleuron of both somites is armed, while it is rounded in *L. kempi.* The stylocerite of *L. paulensis* is intermediate in length between that of the other two species, and the anterior margin of the first segment of the antennular peduncle in *L. paulensis* is more convex than is *L. kempi;* it is concave or straight in *L. tenuicornis.*

Remarks. As already stated, *L. tenuicornis* is primarily a pelagic species. It is adapted to the littoral habit secondarily, perhaps out of necessity. Vast numbers of the species would be killed as *Sargassum* is washed up on shore if they could not adjust to the littoral environment. *L. tenuicornis* is one of the common littoral carideans in Biscayne Bay, Florida. It may be limited to those inshore areas which have more or less similar ecological conditions to those found in oceanic water masses (fairly constant salinity, for example) or it may be limited to those areas which have direct access to oceanic water allowing the sea-weed to reach the inshore area. In this connection, it is interesting to note that *L. tenuicornis* was not collected in northern Florida Bay during the three-year period of an ecological survey there, nor was it reported from Alligator Harbor in northwestern Florida by Wass (1955).

In my opinion, *L. paulensis* is a tropical inshore species derived and now separate from stocks of *L. tenuicornis.*

L. paulensis was taken most frequently in areas where large clumps of red algae, especially species of *Dasya* and *Laurencia,* can be found.

Sandy Key Basin, in Florida Bay off Flamingo, Florida, is a shallow body of water heavily carpeted by the marine grass, *Thalassia testudinum* König, and species of the two genera of algae mentioned above which grow as epiphytes on the grass. Also, the color pattern (cf. color), especially of mature females, is suited for life in the clumps of algae.

This species was common in northern Florida Bay and in nearby brackish water of the extreme southern portion of the Florida peninsula during 1958-1959, but has not been collected since that time. Although the species was most often found in water of normal salinity (ca. 35‰), it can tolerate low salinities, for it was taken in Coot Bay in October, 1958, when the salinities were as low as 16‰.

Size. Ovigerous females ranged from 20.4 to 28.4 mm in total length. Males ranged from 15.0 to 27.7 mm in total length. Measurements of a male 26.3 mm long; scaphocerite length, 5.1 mm; scaphocerite width, 1.3 mm; carapace length, 5.2 mm; length of fifth abdominal somite, 1.8 mm; length of sixth abdominal somite, 2.6 mm; length of telson, 2.7 mm.

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ON THE OCCURRENCE OF THE DACTYLOSCOPID FISH GENUS *DACTYLAGNUS* IN THE WEST ATLANTIC.

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ABSTRACT

A new species of *Dactylagnus* is described from one specimen from Costa Rica. The genus was previously thought monotypic and confined to the eastern Pacific.

INTRODUCTION

Until the present, the genus *Dactylagnus* has contained only the type species, *Dactylagnus mundus* Gill, from the eastern Pacific. Originally described from Isla Carmen in the Golfo de California, it has since been collected from the lower outer coast of Baja California, throughout the Golfo de California, and south to Panamá.

A single individual of a distinct second species of *Dactylagnus* was recently taken from the Atlantic coast of Costa Rica in conjunction with a project on sea turtles directed by Dr. Archie Carr under National Science Foundation grants G-1684 and G-5479. Several subsequent attempts by Mr. Larry Ogren, the collector of our one specimen, to recollect the species have been unsuccessful, but the species is sufficiently distinct that we feel no hesitation in naming it without more material. More recent visitors to the area also have tried, unsuccessfully, to obtain additional material. This and other fishes collected in the same area have been listed by Caldwell, Ogren and Giovannoli (1959).

Dactylagnus peratikos new species

Description.—Eyes large, supralateral in position, more superior than lateral in direction. Anterior nostrils tubular, with a short fleshy tab on the posterior margin of the rim. Posterior nostril a simple hole without raised margins, lying on a line between anterior nostril and mesial margin of eyeball. Teeth on jaws uniserial, rather long sharp and conical, somewhat stronger laterally than in front. Teeth absent

FIGURE 1. *Dactylagnus peratikos:* holotype, UF 7176, 42.7 mm in standard length.

from the palate. Tongue free, its tip broadly rounded. Premaxillaries without a median frenum, greatly protractile. Rear margin of maxillary below a point just behind mid-eye. Lower jaw strongly projecting. Both upper and lower lips with a fringe of elongate fleshy papillae, those of the upper lip consisting of forward extensions from the lip itself, those of the lower lip dorsal projections from the edge of the lip; the lower lip papillae are the longer. Seventeen papillae around the face of the upper lip and 23 projecting upward from the lower lip. Preopercles with broad free membranous margins. Opercles membranous, very extensive—overlapping the bases of the ventral fins below. Gill membranes narrowly united far forward, just before the spine-like projection which is the anterior point of union of the two pelvic bones. Opercles with radiating striations throughout; dorsally these opercular striations end in a group of long narrow separated finger-like projections—the opercular fringe. There are 10 of these projections on each side of the fish; the remainder of the membranous opercular margin is entire. Branchiostegals 6. Pseudobranchia well developed. Gills 4, with an opening behind the last. No gill rakers present. Mouth oblique.

Rather large thin cycloid scales present on body, absent from head and nape. Lateral line on body strongly arched for a short distance anteriorly, median for its greater extent. Sixteen scales in the arched portion of the lateral line, which portion terminates before the tips of the appressed pectorals, and 33 scales in the median lateral portion —or a total of 49. The type has a transverse scale count of 11 at about the level of the down curve of the arched portion of the lateral line. The lateral line is deflected distinctly downward on the final scale of the mid-lateral series at the caudal-fin base. There are no basal scales

on any of the fins except the caudal, where several scales form a sheath one scale row in extent at its base. Belly naked.

Dorsal and anal fins both very long, their spinous and segmented portions continuous. The dorsal fin with 10 weak spines and 29 longer segmented rays, the interradial membranes of both portions incised; anterior interspinal membranes not so deeply incised as to indicate separate little finlets (as is the case in certain species of *Dactyloscopus* and *Heteristius*), and none of the anterior spines unequally spaced. Origin of dorsal fin well behind head but in advance of anus, the first anal spine falling below the interspace between dorsal spines 2 and 3, Anal fin with 2 spines and 34 longer segmented rays, the spines and rays similarly incised. The membranes behind the final dorsal and anal segmented rays attached to the peduncle at the level of the anteriormost accessory caudal rays. Caudal fin truncate, with 10 segmented rays of which the uppermost and lowermost are unbranched. Pectoral fins rather long and pointed, extending posteriorly to the 6th segmented anal ray or to one or two scales past the arched portion of the lateral line. Pectoral rays 13 on either side, all of them unbranched; the interradial membranes of the lower half of the fin incised, those of the upper half entire. Dorsal, anal and ventral segmented rays unbranched. Ventral fins far in advance of pectoral base, each consisting of one very small spine and three nearly equal segmented rays; the spine closely applied to the first segmented ray, the succeeeding rays with deeply incised membranes between them. Ventral-fin rays with thickened membranes surrounding them.

The body is deepest at the origin of the dorsal fin. Posterior to the point of greatest depth the dorsal and ventral body outlines taper down to a narrow peduncle—both sagging somewhat so that the dorsal outline is a bit concave and the ventral a bit convex. Anterior to the point of the greatest body depth the dorsal outline is concave to the extent that there appears to be a slight hump in the outline at the origin of the dorsal fin.

Since the anal spines are both rather short, curved posteriorly and incised as the rays of the remainder of the fin, the type specimen is probably either a female or very young male for the spines in adult males of related dactyloscopids take on a very different and distinctive character.

Proportions. The following are measurements of the holotype expressed as thousands of the standard length (42.7 mm): greatest body depth 165; snout to dorsal origin 252; snout to anus 298; long-

est caudal ray 140; length of head 236; diameter of eye 047; length of snout 040; length upper jaw 080; snout to anterior angle of preopercle 129; snout to posterior angle of preopercle 159; greatest head width 136.

Coloration in alcohol. The color pattern is difficult to express in writing and is best appreciated by referring to the accompanying photograph. The markings are brownish on a cream colored background.

Coloration when freshly preserved. The basic color was said to be dark caramel, and the dark markings a dark chololate brown.

Relationships. The new species differs from the only other described species in the genus, the eastern Pacific *D. mundus,* in many respects. It has fewer anal and pectoral-fin rays and fewer scales in the straight portion of the lateral line than does its eastern Pacific relative (Table 1). It apparently also has fewer lobes in the opercular fringe and fewer lower lip papillae than does *mundus.* While the point of origin of the dorsal fin is approximately the same in the two species, the anus of the new species is set much further back so that the relationship between the origins of dorsal and anal fins is quite different. Thus also the pectoral fin of *mundus* reaches back much further on the anal fin than to the base of the sixth segmented ray than it does in the new species. The new species has apparently only a single series of teeth on the jaws whereas the dentition of *mundus* is in at least several series anteriorly. The new species has notably larger eyes and a narrower interorbital than does *mundus* and while more heavily pigmented than comparable *mundus,* lacks the little dorsal saddles which characterize *mundus* of the size of the holotype of the new species. *D. mundus* is a much more broad and heavy fish anteriorly than is the new form. The proportional distinctions mentioned above will be treated more specifically in a revision of the entire family Dactyloscopidae which the senior author has in progress. However, the meristic differences of Table 1 alone will serve easily to distinguish the two forms. Of these, perhaps the differences in anal and pectoral-ray counts are the most distinctive.

Habitat. The general ecological conditions at Tortuguero have been described previously (Caldwell, Ogren and Giovannoli 1959), and it was noted therein that our present specimen (as "*Dactylagnus* sp.") was collected at the surf line on an open sand beach. Ogren reported that he scooped up the specimen with his hand as it buried itself upon the retreat of a wave. Several observers have told us that a heavy

TABLE 1

FIN-RAY AND SCALE COUNTS OF THE HOLOTYPE OF *Dactylagnus peratikos* AND OF 163 SPECIMENS OF *Dactylagnus mundus* FROM THE EASTERN PACIFIC.

	Dorsal Spines				Dorsal Rays						Total Dorsal					
	IX	X	XI	XII	29	30	31	32	33	34	39	40	41	42	43	44
peratikos		1			1						1					
mundus	21	120	21	1	15	62	63	14	8	1	18	61	56	17	10	1

	Segmented Anal Rays									Pectoral Rays			
	34	35	36	37	38	39	40	41		13	14	15	16
peratikos	1									2			
mundus			15	71	55	15	6	1			11*	276	39

	Lateral-Line Scales																							
	Arched						Straight							Total										
	14	15	16	17	18	19	33	34	35	36	37	38	39	49	50	51	52	53	54	55	56	57	58
peratikos			1				1							1									
mundus	2	15	95	40	7	3	1	9	59	63	21	7	2	2	10	43	60	28	16	1		1	1

*Only one specimen had 14/14 pectoral rays; all other 14 counts were on one side only, a 15 count present on the other.

surf is almost always present along this stretch of coast. Since the beach in the area of collection slopes sharply into rather deep shark-infested water, no attempts have been made to determine if the species lives in the deeper sands.

The beach was of black volcanic sand and the dark coloration of the recently preserved specimen probably reflects an adaptation to it.

Material examined. HOLOTYPE: UF 7176 (42.7 mm in standard length), Ogren sta. 451, Tortuguero beach, Limon Province, Costa Rica (Atlantic side): 10°34′N, 83°32′W, July 30, 1958, L. H. Ogren.

Name. The specific name *peratikos* (Gr.) means alien, foreign, dwelling on the other side — in reference to the distribution of this species as compared with that of its congener in the eastern Pacific.

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CHARTING THE MARINE ENVIRONMENTS OF ST. JOHN, U.S. VIRGIN ISLANDS[1]

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AND

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ABSTRACT

By use of the diving sled in conjunction with aerial photos charting of the marine biotopes of St. John, Virgin Islands was carried out expediently and accurately. The method of operation of the diving sled is discussed and possible application to other phases of aquatic investigation are mentioned. The chart of the marine environments of St. John is figured.

INTRODUCTION

In 1956 more than 5000 acres on the island of St. John in the United States Virgin Islands were dedicated as the twenty-ninth national park. The waters adjacent to the park are consistently clear and contain coral-reef areas which are recognized by the National Park Service as a significant reserve. The waters are also of value for sportfishing and other forms of aquatic recreation.

In 1958, as a first step toward an understanding of the marine areas of the Virgin Islands National Park, a marine biological survey of St. John was commenced by The Marine Laboratory of the University of Miami under a contract with the Virgin Islands Government and a grant from the National Science Foundation. Research facilities on the island were provided by the National Park Service. Charting the major marine environments of St. John to the 10-fathom curve was proposed as one project of the investigation.

St. John is 8 miles (east-west) long, nearly 4 miles in greatest width (north-south), and 19.2 square miles in area. The shoreline is much more dissected than most oceanic islands. Furthermore, fairly deep water occurs close to shore, especially off headlands; ten fathoms may be found within 200 feet of Ram Head and Mary Point. This, and the lack of highly developed coral reefs, suggest that the island has experienced subsidence. These effects seem greater than would be produced by the rise in sea level accompanying the melting of the last great

[1]Contribution 348 from The Marine Laboratory, University of Miami. This work was supported with Federal Aid in Fish Restoration funds of Dingell-Johnson Project No. F-2-R and National Science Foundation Grant No. 5941.

glaciers. Meyerhoff (1927: 559) stated that differential warping has partly drowned the Virgin Islands area.

The shoreline of St. John and nearby cays slightly exceeds 58 miles. In view of the large area to be surveyed, some efficient method was needed if the task were to be completed with dispatch.

Method

The only available chart of the entire island of St. John is the United States Coast and Geodetic Survey chart number 905 which also includes St. Thomas, St. Croix, and nearly all of the British Virgin Islands. As would be expected it is not detailed for any one island. On C.&G.S. chart number 938 of Pillsbury Sound, the 1.8-mile wide channel separating St. John from St. Thomas, the western portion of St. John only is shown in detail.

A request was made to the U. S. Coast and Geodetic Survey for a work sheet that covered all of the waters adjacent to St. John. A large smooth sheet (Register No. 4743a), based on a survey ending December, 1924, and containing numerous soundings and scattered notations of bottom type was thus obtained. Few additional soundings were found necessary. Since detailed soundings or numerous bottom contours cannot be clearly presented on the same chart with symbols for the various kinds of bottom only the 5- and 10-fathom contours are shown on the final chart.

A series of thirteen aerial photographs of St. John, dated January 29, 1954, was obtained from the U. S. Geological Survey. Part of one that includes Lameshur Bay, on the south shore of St. John, the base of operations of Marine Laboratory personnel, is shown in Figure 1. These photographs have proved of great value for charting. Sandy areas appear light in the photos, the broad expanses of sea grass, (primarily *Thalassia* and *Cymodocea=Syringodium),* are uniformly dark and coral areas generally mottled dark. One feature, a band of sand of average width of about 30 feet, may frequently be seen (Figure 1A) separating inshore coral and rock regions from offshore sea grass areas. John E. Randall (1960) has demonstrated that this region may be caused primarily by grazing of herbivorous fishes, especially parrotfishes. This sandy strip was most useful for distinguishing the two different major bottom types which are dark on the photographs. In some regions it would be possible to map the major marine habitats from aerial photos alone with fair accuracy; however, most areas presented problems which required direct observations of the bottom.

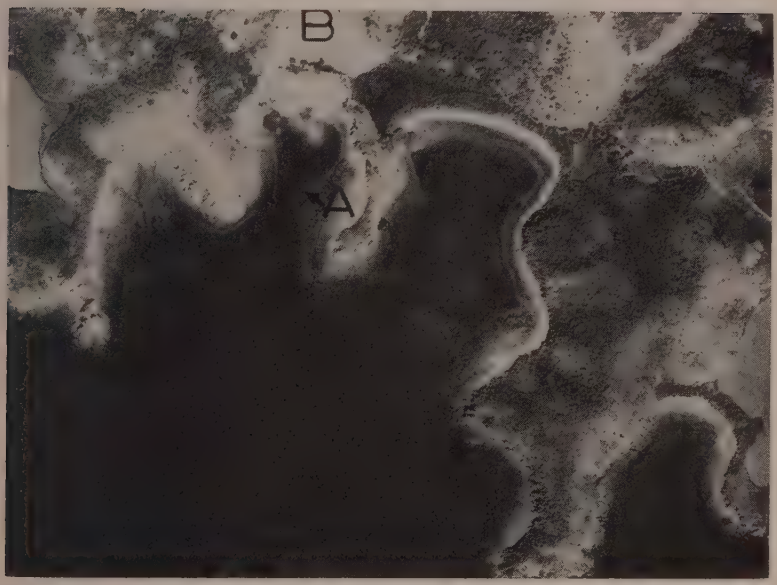

FIGURE 1. Aerial Photo. Southeast shore of St. John, U. S. Virgin Islands. A—Band of Sand. B—Location of temporary marine field station.

To facilitate observation of the bottom, a simple diving sled (Figures 2 and 3) was used. This was constructed of one-inch marine plywood by project leader John E. Randall at a cost of materials of less than 3 dollars. A sheet of lead weighing eight pounds was later added to offset the buoyancy of the wood. The 33-foot vessel PARK RANGER was used to pull the sled. Most bottom observations were made by Herman Kumpf, the rest by John E. Randall. The recorder in the vessel was Helen Randall.

A dive is made while being towed by depressing the front of the board with action of the wrists. When the desired depth is reached the board is nearly leveled. A slight upward turning of the wrists results in a rapid return to the surface. The greater the length of tow line, the more readily the observer can descend. A limitation to the length of tow line is the need to be close enough to the recorder to permit verbal exchange. A distance of 58 feet from sled to boat (of which 6 feet is the length of the bridle to the sled) is suitable. A depth of 40 feet can be attained with use of this length of tow line. In addition to reporting

Results

Figure 4 represents the biotopic chart of the marine environments of St. John. Only the major bottom types are plotted. These are hard bottom (coral and rock), sea grass, mud and sand. Mangrove areas that are continuous to the sea are indicated by the appropriate symbol on land. The usual U. S. Coast and Geodetic Survey symbol for reef is used for extensive areas of both coral and rock. It proved impractical to distinguish between predominately live coral areas and those areas consisting mostly of rock because there is no sharp division between the two. Along the shore, and especially off the promontories, there are often boulders of land origin over which variable amounts of corals and alcyonarians are growing. Regions in which small isolated coral heads or coral patches occur are indicated by small crosses. Sea grass beds are shown by stippling; when growth is sparse, the stippling is less dense. Mud areas are indicated by close-set parallel lines. Sand is designated by no symbols at all. Included with sand are regions of gravel, small stones, and coral rubble, which may or may not have an overgrowth of algae. In general these areas of sand and gravel appear pale on aerial photographs. Although different plant and animal associations may exist on these substrates, as well as differences with depth and hydrographic conditions, they are not distinguished because of adding undue complexity to the chart.

One objective of the survey was to ascertain the most attractive shallow-water reef areas for visitors to the Virgin Islands. These were found at the west side of Haulover Bay, Anna Point (east end of Mary Peninsula), Mary Creek (just west of Annaberg Ruins), and Friis Bay to Lagoon Point in Coral Bay. The reef parallel to shore at Haulover Bay is the best example of a typical fringing reef on St. John.

The sea grass beds consist primarily of turtle grass *(Thalassia)* and manatee grass *(Syringodium)*. These two plants are frequently seen growing together. *Syringodium* dominates in deeper water and has been observed growing at depths as great as 70 feet. Most of the inshore aquatic substratum of St. John to the 10-fathom curve consist of beds of sea grass. To the casual observer the grass beds seem devoid of fish. However, they contain many fishes including juveniles of many of the fishes which when larger inhabit the coral reefs.

Six mud areas exist in the waters of St. John, all in protected areas at the heads of shallow bays. Three are located in Coral Bay (one in Coral Harbor and two in Hurricane Hole), one in Fish Bay, one at Mary Creek, and another in Cruz Bay. All merge into *Thalassia* at

64°48'
47'
46'
45'
ATLANTIC
WHISTLING CAY
JOHNSONS REEF
DURLOE CAYS
HAWKSNEST PT.
TRUNK BAY
CINNAMON BAY
HAWKSNEST BAY
CANEEL BAY
LIND PT.
PILLSBURY SOUND
ST.
SCALE 0 ½ 1 MILE
FIVE FATHOM LINE
TEN FATHOM LINE
CRUZ BAY
TURNER BAY
GREAT CRUZ BAY
RENDEZVOUS BAY
FISH BAY
CONTANT PT.
CHOCOLATE HOLE
BLASBALG PT.
BOVOCOAP PT.
DITTLIF PT.
MAJOR MARINE ENVIRONMENTS OF ST. JOHN
BASED ON SURVEY BY H.E. KUMPF AND H.A. RANDALL
OF
THE MARINE LABORATORY
UNIVERSITY OF MIAMI
1958-1959
CARIB

FIGURE

42'
41'
40'
64°39'
PT.
BROWN BAY
PRINCESS CREEK
BORCK CREEK
RAL HARBOR
HARBOR PT.
HURRICANE HOLE
TURNER PT.
HAULOVER BAY
NEWFOUND BAY
EAST END BAY
EAST END PT.
ROUND BAY
PRIVATEER BAY
PRIVATEER PT.
SAUNDERS BAY
LAGOON PT.
CORAL BAY
LONG PT.
JOHNSON BAY
FRIIS BAY
SABBAT PT.
JOHN'S FOLLY BAY
DRUNK BAY
SALT POND BAY
RAMHEAD PT.
SEA
N
W
E
S
21° 30"
18° 19'
42'
41'
64°40'

ds.

their seaward margin and run up into the intertidal zone where they are bordered by mangroves. In Coral Bay the upper, soft, brown mud is laid upon a shelly, sulfurous mud substratum. Clarity of the water in these areas is poor.

Three common species of American tropical mangroves are found on St. John: *Rhizophora mangle*, the red mangrove, *Avicennia nitida*, the black mangrove, and *Laguncularia racemosa*, the white mangrove. No distinction on the chart was made between them as they commonly grew together. However, all three are not necessarily present at each mangrove symbol.

Remarks

Using the sled along with aerial photos and smooth sheets the charting of the marine biotopes was carried out expediently and accurately. This is the first time that a diving sled has been reported utilized in an ecological investigation. This method, in the hands of trained personnel, could be applied to similar studies of aquatic biotopes, preliminary geological studies, environmental surveys and fisheries investigations.

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A CHECKLIST OF THE FLORA AND FAUNA OF NORTHERN FLORIDA BAY AND ADJACENT BRACKISH WATERS OF THE FLORIDA MAINLAND COLLECTED DURING THE PERIOD JULY, 1957 THROUGH SEPTEMBER, 1960[1]

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ABSTRACT

Four hundred thirty two species of plants, invertebrate animals and fish are reported from the marine and brackish-water areas of northern Florida Bay and adjacent estuaries. Notes on their abundance, tolerance to change in the physical environment, and distribution in relation to habitat are included. This work was done in order that their fluctuations in distribution and abundance in a natural environment might be better understood. This information could eventually aid in interpreting changes in populations due to man-made alterations in shallow water.

INTRODUCTION

One problem in conservation of our natural resources lies in the tremendous increase in human population which brings humans and animals in direct competition for living space. When a state has warm winter climate, extensive sea-shores and some of the best recreational and commercial fishing, as is the case in Florida, the problems associated with increasing resident populations are complicated by heavy tourism. In Florida the problem is further complicated by the peculiar topography of the southern half of the state which is shaped somewhat like a giant platter filled with water. The greater portion of available dry land lies along the narrow east and west rims of the platter.

The southeastern quarter of the state of Florida where population growth is greatest, and where high land is least abundant, has already reached the point where marginal land must be developed. Usually, this is accomplished by filling in edges of bays, using spoil obtained by dredge from farther out in the shallow bottoms. These activities inevitably create a conflict of interests as conservation groups and private citizens see first one and then another of their favorite fishing spots destroyed or altered.

The destruction of fishing areas, bird rookeries and migratory water-

[1]Contribution No. 354 from The Marine Laboratory, University of Miami.

fowl wintering areas by dredging and bulkheading is serious. Even more serious, however, is the potential threat to our coastal resources by the completed and contemplated reclamation projects that affect entire major river systems that empty into coastal estuaries.

In 1957, the Florida State Board of Conservation, concerned over increasing numbers of dredge and fill applications, provided funds to The Marine Laboratory of the University of Miami to conduct long-

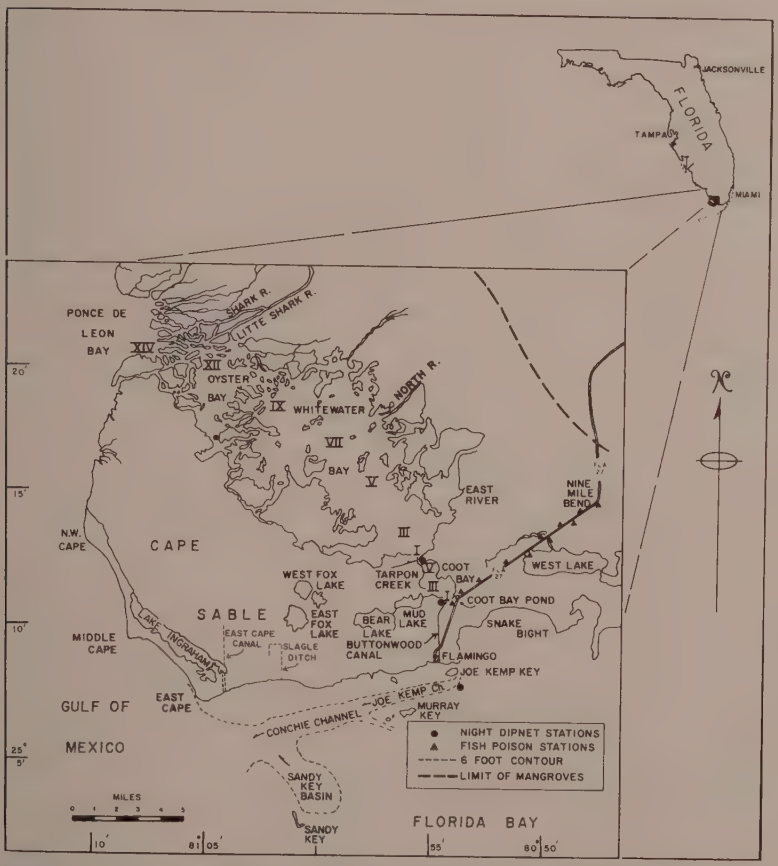

FIGURE 1. The Cape Sable region of northern Florida Bay with major place names and collecting locations. Poison stations run from Coot Bay Pond along highway 27 to Nine-mile Bend; Roman numerals indicate hydrographic stations.

term studies of estuarine ecology in one of the few areas in South Florida that had not been affected to any extent by man-made alteration. It was decided that the marine and brackish-water environment of northern Florida Bay within the boundary of Everglades National Park (Figure 1) most nearly conformed to the requirements of the study. The protective policies of the United States National Park Service insured relative stability of the area from a reclamation standpoint. That it was impossible to find any other area of similar size in South Florida for this study that had not already received major changes emphasizes the magnitude of the problem.

The survey area was one in which the plants and animals found were living in an undisturbed environment. Information obtained on the changes in distribution of the biota in response to variation in this undisturbed physical environment could be used as a basis for future studies of similar organisms in areas undergoing reclamation.

The investigation was conducted as follows: 1. Collections were made in all shoreline areas with particular attention being paid to the broader categories of emergent and intertidal habitats. 2. Collections were made of the marine fauna of surface and midwaters. 3. Collections were made of the bottom flora and fauna in all possible environmental situations. 4. Studies were made on the gross composition of the substratum and data were gathered on the biota associated with each broad substratum category. 5. A hydrographic survey was conducted in conjunction with the faunal studies.

This paper consists of an annotated list of the macroscopic flora and fauna of northern Florida Bay and associated brackish to freshwater areas of the adjoining mainland. These collections and observations were made during the period July, 1957, through September, 1960.

Literature

Prior to the beginning of this study in 1957, there had been practically no biological work done on the marine environment of the area in question. Short references had been made by Henshall (1891) on fishes of the Cape Sable region, and on crustaceans by Rathbun (1918, 1925, 1930, 1937) and Holthuis (1951, 1952). One of the most interesting works to be found on the area is a survey of mangroves by J. H. Davis (1940) but only passing reference was made by him to the aquatic fauna associated with mangroves. Three papers have been of interest since they provide most of the historical data available

concerning the hydrography of the area prior to the beginning of this study. C. C. Davis (1948, 1950) studied the plankton and hydrography of West Lake and similar ponds just east of the present survey area. Finucane and Dragovich (1959) present valuable observations on the hydrography of the area during a severe drought period.

Collecting Areas

The collections made during the study were taken from many different environmental situations with whatever gear or method seemed best for the particular situation. For the sake of simplicity, the entire study area can be divided into six areas based on broad habitat similarity. The individual stations within these areas are shown (Figure 1). Beginning off-shore in Florida Bay, there are three main habitat types, based mainly on bottom material, vegetation, water clarity, depth and salinity. They are as follows:

Conchie Channel.—Bounded on the west by a line drawn between East Cape Sable and Sandy Key. This area is characterized by moderate to heavy turbidity, depths from 2 to 9 feet and having coarse shell, shell sand or hard marl mud bottoms. The shallow banks adjacent to Conchie Channel are heavily vegetated, usually with *Thalassia testudinum,* but the channel proper contains only sparce amounts of vegetation as a result of current scouring, high turbidity and greater depth. Salinity in this area fluctuates normally between 30 and 40‰.

Sandy Key Basin.—Immediately south of Conchie Channel, with moderate current, very light turbidity and exceptionally heavy growths of marine plants. The bottom grades from soft shelly mud to coarse shell patches. Water depth varies from one foot on the shallow banks to 7 feet in mid-basin. Salinity values are stable usually varying between 30 and 40‰.

Joe Kemp Channel.—The area east of Conchie Channel, including adjacent shallow banks, to Joe Kemp Key. Characterized by strong tidal scouring, exceptionally heavy turbidity and widely fluctuating salinity, between 25 and 45‰ in years of normal rainfall and have been measured as high as 70‰ in drought periods (Finucane and Dragovich, 1959). Depths range from 0 to 7 feet. The bottom consists of fine marl muds with shell inclusions on the banks, and hard mud with rock outcrops in the deeper parts of the channel off Joe Kemp Key. The bottom is subject to current scour and re-deposition of marl muds during severe storms. Turtle grass, *Thalassia testudinum,*

dominates on the shallow banks and several species of algae, notably *Caulerpa* species are dominant in the channel.

Inshore waters fall into three additional categories based on habitat differences.

The mangrove swamp.—Stations in this environment are typified by Coot Bay Pond, West Lake, Bear Lake and smaller bodies of standing water along the Park highway between Flamingo and Nine-mile Bend (Figure 1). Characterized by shallow water, generally less than 2 feet. These areas are rich in organic leachings and having water normally dark coffee color. High marsh gas and low dissolved oxygen content are characteristic. Salinity fluctuations are wide, varying with local rainfall as well as with mainland run-off.

Coot Bay and Eastern Whitewater Bay.—Characterized by soft marl bottom containing locally produced shell sand and coarse shell fragments as well as large quantities of organic material derived from the surrounding mangroves. An area of wide salinity fluctuations seasonally (5-30‰) but stable on a daily basis due to minimal tide exchange. Probably this was an area of continuous low salinity prior to the opening of Buttonwood Canal into Coot Bay from Flamingo. This opening has increased salinity values in Coot Bay. Average depth 3 to 4 feet although this may increase slightly as a result of fresh-water accumulation from the mainland in years of above average rainfall.

Western Whitewater Bay and the Shark River.—Estuarine, with moderate to strong daily tidal cycle and large flow of fresh-water from the Everglades Floodway during the rainy season. Diurnal variation in salinity may be as high as 20‰, averaging 5 to 10‰. Seasonal variation in salinity about 20‰ throughout the area. Water depth 4 to 12 feet, tidal variation in the Shark River mouth 1 to 3.5 feet. The bottom ranges from pitted limestone in the main river channels to peaty marl in the open bays. Dominant vegetation several species of green and brown algae.

The Marl Prairie.—Characterized by the presence of xerophytic vegetation, water levels that fluctuate with rainfall, and, with extremes of temperature and exposure to sunlight. Soil mainly fine grained marl that fractures in vertical planes when dry.

Methods

Collections were made by all the usual types of gear employed for such work. These included the 12-foot otter trawl, van Veen bottom

grab, small-mesh seines, fish toxicants, traps, night-light dipnetting and small-mesh channel nets. In addition, pushnets and hand picking were employed whenever water clarity or bottom firmness permitted. Records of angler catches were also examined to provide observations on some of the larger fishes not easily collected by the gear described.

Our policy in this paper has been to list first the scientific name, then the common name if a well known one is available, the text and finally the salinity and temperature data. In some cases, collections were not sufficiently complete to allow presentation of ranges of these conditions. In this event, we simply present the observed salinity (OS) in parts per thousand, the observed temperature in degrees Centigrade (OT) or both if available. Sufficient samples were taken of a majority of species to allow realistic estimates of the salinity and temperature ranges normally undergone by them. Temperature and salinity data that have been collected repeatedly have been presented as (OSR) and (OTR) or observed salinity range and observed temperature range, respectively. In cases where temperature or salinity values have been far above or below the majority of observations for a particular species, thus indicating a high degree of tolerance for at least short periods of time, we have set the low readings to the left and high readings to the right of what we have observed to be the normal range. These values if available, are set off by semicolons, *e.g.*, low salinity reading observed is 0‰, the normal range we observed is 15-35‰, the upper limit is 50‰, this would be given as 0; 15-35; 50.

Representative samples of most plants and animals collected have been deposited at The Marine Laboratory for future study. Duplicate series have been kept of some groups for distribution.

Acknowledgments

The authors wish to express their appreciation to The Florida State Board of Conservation, Mr. Ernest Mitts, Director, and its Director of Research, Mr. Robert Ingle for providing the funds necessary for important long-term studies, and for providing advice and encouragement during the progress of the survey. We are grateful for the assistance given by David Dubrow in assembling the hydrographic data used here and for his untiring efforts in the arduous field and laboratory routine. Appreciation is hereby extended to the specialists that took valuable time from their own studies to identify material sent to them. These are Dr. C. Richard Robins, Dr. Richard D. Wood, Dr. Harold Humm, Mrs. Elizabeth Alexander, Mr. Robert Work,

Mr. Lowell P. Thomas, Dr. Harding P. Owre, Mr. Donald Moore, Mr. Donald S. Erdman, Dr. Gilbert L. Voss and Dr. Fenner A. Chace, Jr.

We are particularly grateful to Dr. C. P. Idyll and to Dr. Edwin Iversen and Dr. Albert Jones for their guidance throughout the course of the study and for their thankless but necessary additional work on this manuscript.

Finally, we express our appreciation to Mr. Warren Hamilton, Superintendent of Everglades National Park and the courteous staff of that organization for providing facilities and assistance whenever needed. Without their cooperation, this study would not have been possible and it is gratefully acknowledged.

Marine Plants

The following list presents the majority of the larger marine and brackish-water plants that are most often encountered in the study area. They have been identified by the junior author and Mrs. Elizabeth Alexander of The Marine Laboratory. Dr. Richard D. Wood, Department of Botany, University of Rhode Island, identified the single species of chara, *Chara hornemannii* Wallman, that occurs most abundantly in the fresh to slightly brackish areas of South Florida.

Papers by Taylor (1928, 1960) were used for the majority of identifications. In addition, studies on the marine algae of the Florida Keys (Voss and Voss, 1955) and the seagrasses of Florida (Phillips, 1960) were used for comparison with the flora in adjacent marine areas.

MARINE ALGAE

Division *CHLOROPHYTA*

Family Cladophoraceae

Cladophoropsis sp.

Central Whitewater Bay during periods when salinities rise above 25‰. OSR 26-36

Family Dasycladaceae

Acetabularia crenulata Lamouroux Venus Wine Glass

Western Whitewater Bay to Station VIII, central Whitewater Bay, when salinities rise above 15‰. Very common throughout the area

from July, 1957, through June, 1958. Scarce since that time, becoming abundant only during April and May dry season high salinity periods. OSR 15-36

Batophora oerstedi var. *occidentalis* (Harvey) Howe

Coot and Whitewater Bays, Shark River, shoreline of Florida Bay (uncommon), and Bear Lake, West Lake and similar brackish to fresh areas. OSR 0-35

Family Codiaceae

Udotea wilsoni (Ellis and Solander) Howe

Western Whitewater Bay between Stations X and VI where it grows in such abundance as to effectively exclude most other species of attached algae. An unbroken mat of this species, approximately two miles long and one-half mile in width, stabilizes the marl bottom against wind and tidal currents to such an extent that the area is called Clearwater Pass. Found elsewhere in Whitewater and Florida Bays as patches or individual plants. Prolonged salinities lower than 10‰ cause the plants to shed the blade-like upper portions. The club-like stems and "root ball" remain viable for long periods and recover rapidly with rising salinities. OSR 10-38

Family Caulerpaceae

Caulerpa crassifolia (C. Agardh) J. Agardh

In the deeper water of Joe Kemp and Conchie Channels off Flamingo. OSR 30-38

Caulerpa cupressoides (West) C. Agardh

In Conchie Channel growing in marl mud. OSR 30-38

Caulerpa prolifera (Forskal) Lamouroux

Florida Bay and the western half of Whitewater Bay during periods of high salinity. OSR 21-38

Caulerpa sertularioides (Gmelin) Howe

Florida Bay in deeper, muddy-bottomed channels, and in central Whitewater Bay where it occurs in great abundance at certain salinities. It vies with *Acetabularia* and *Batophora* for dominance of the area of Whitewater Bay between stations V and VII. The three species show marked succession in relation to salinity with *Batophora* flourishing during periods of low salinity and *Acetabularia* occuring in

greatest profusion during periods of high salinity. All the Caulerpas listed here are found most abundantly in clear water and are quickly decimated by prolonged marl turbidities such as those that have prevailed in the inshore zone of northern Florida Bay in the vicinity of Flamingo. OSR 21-38

Caulerpa verticillata J. Agardh
East and central Whitewater Bay. OSR 16-36

Family Characeae

Chara hornemannii Wallman

Northeast Whitewater Bay, Coot Bay and the shallow brackish to fresh-water lakes north and east of Coot Bay (West Lake, Nine-mile Lake, and Paurotis Lakes). It reaches its greatest size and density when salinity values fall below 15‰. In Coot Bay it alternates with *Ruppia maritima* and *Diplanthera wrightii* (*i.e., Chara* at the lowest values, *Ruppia* when values lie between 12 and 28‰ and *Diplanthera* when salinity values rise above 28‰). OSR 0-12; 28

Division *PHAEOPHYTA*
Family Dictyotaceae

Dictyota cervicornis Kuetzing
Florida Bay. OSR 32-37

Family Fucaceae

Sargassum filipendula C. Agardh

Uncommon, but found throughout Florida Bay off Flamingo, and in western and central Whitewater Bay during periods of high salinity. The rather wide range of salinity under which this species has been observed was unexpected. However, the fact that all the individual plants observed in the lower salinity of Whitewater Bay were attached indicated that they did not enter the area as tidal drift from off-shore. OSR 18-35

Division *RHODOPHYTA*
Family Rhodophyllidaceae

Euchema isiforme (C. Agardh) J. Agardh
Florida Bay. OS 32

Family Sphaerococcaceae

Gracilaria confervoides (Linnaeus) Grenville
Central and western Whitewater Bay during periods of high salinity;

abundant in Florida Bay, mixed with *Thalassia testudinum*. (Several species are probably present, but this group is virtually unidentifiable at present.) OSR 20-38

Hypnea musciformis (Wulfen) Lamouroux
Western Whitewater Bay.

Family Rhodomeniaceae

Chrysemenia uvaria (Linnaeus) J. Agardh
Florida Bay. OS 34

Chrysemenia planifrons (Meluill) J. Agardh
The Shark River channel at Ponce de Leon Bay during the periods January through April when salinities are highest. OSR 32-37

Family Rhodomelaceae

Acanthophora spicifera (Vahl) Bφrgesen
Central and western Whitewater Bay during periods of high salinity. Common in clear water of Sandy Key Basin off Cape Sable. OSR 16-36

Dasya pedicellata (C. Agardh) C. Agardh
Central and western Whitewater Bay; Sandy Key Basin off Cape Sable. Reaches its greatest height (up to 12 feet) in the main channel of the Shark River where that river joins Ponce de Leon Bay. OSR 21-33

Laurencia intricata Lamouroux
Western Whitewater Bay; Florida Bay in Joe Kemp Channel and in Sandy Key Basin off Cape Sable. OSR 14-35

Laurencia poitei (Lamouroux) Howe
Florida Bay intermixed with *Thalassia testudinum*. OSR 31-35

Family Grateloupaceae

Halymenia floridana J. Agardh
Western Whitewater Bay in the rocky tidal channels. OS 34

MARINE PHANEROGAMS
EMBRIOPHYTA MONOCOTYLEDONEAE

Family Hydrocharitaceae

Halophila engelmanni Aschers
Florida Bay in widely scattered locations, usually in clear water areas. Uncommon in the survey area. OSR 28-37

Thalassia testudinum König — Turtle Grass

The dominant "grass" of Florida Bay on the marl banks. OSR 28-48

Diplanthera wrightii Aschers

Coot Bay, Florida Bay in the Snake Bight and Sandy Key Basin areas. Found in shallow water in soft muds heavily charged with organic material (plant fragments). Occurs in dense patches along the mainland shore in the Snake Bight area and mixed with *Thalassia* in the Sandy Key Basin area. Reaches its greatest development in clear water. During the rainy season when inshore salinity values decrease markedly, it may be replaced by Widgeon grass, *Ruppia maritima*. OSR 7-38

Ruppia maritima Linnaeus — Widgeon Grass

Coot Bay, sparsely scattered in eastern Whitewater Bay; along the shoreline of Florida Bay in the Snake Bight area during periods of prolonged low salinities. Reaches its greatest length (to 2 meters) in Coot Bay during the flowering period, mid-April through July. Growth of the plants is rapid in the spring preceeding flowering, and the surface of eastern Coot Bay becomes carpeted by a matt of plants that are several feet longer than the depth of the water. Following maturation there is a rapid dying back to the mud line. If, during the following winter, salinity values rise to 15 to 20‰, *Diplanthera* springs up to replace *Ruppia*. In Coot Bay, if salinities fall below 10‰, both *Ruppia* and *Diplanthera* give way to the calcareous alga *Chara hornemannii*. OSR 4-28

Syringodium filiforme Kützing
(*Cymodocea manatorum* Aschers)

Sandy Key Basin in Florida Bay. OSR 28-37

Sponges

Sponges were identified by Mr. Robert Work of The Marine Laboratory using papers by de Laubenfels (1936, 1948, 1949, 1950 and 1953). This list of sponges is probably far from complete since the present survey area lies just east of the extensive sponge grounds off Cape Sable in the Gulf of Mexico. All sponges listed are relatively common, however, in the deeper water of the channels in Florida Bay.

No information on salinity or temperature ranges has been included since, in most cases, collections were made only for identification.

Order KERATOSA (or KERATOSIDA)

Family SPONGIIDAE

Ircinia campana (Lamarck) Vase Sponge
Florida Bay off Cape Sable.
Ircinia fasciculata (Pallas)
Florida Bay off Cape Sable.
Verongia longissima (Carter)
Florida Bay off Cape Sable.

Family DYSIDEIDAE

Dysidea fragilis (Montagu) Johnston
Conchie Channel to Middle Cape Sable in Florida Bay.

Order HAPLOSCLERINA (or HAPLOSCLERIDA)

Family HALICLONIDAE

Haliclona viridis (Duchassaing and Michelotti)
Florida Bay in six to ten feet of water, becoming most abundant off Cape Sable.

Family CALLYSPONGIIDAE

Callyspongia procumbens (Carter)
Conchie Channel to the deeper waters off Cape Sable.

Family TEDANIIDAE

Tedania ignis (Duchassaing and Michelotti) Fire Sponge
Deeper water from East Cape Sable westward in Florida Bay.

Family AXINELLIDAE

Homaxinella rudis (Verrill)
Florida Bay in Conchie Channel and off Cape Sable.

Order HADROMERINA (or HADROMERIDA)

Family PLACOSPONGIIDAE

Placospongia melobesiodes Gray
Florida Bay off Cape Sable.

Family CLIONIDAE

Cliona caribboea Carter
In deeper water of Joe Kemp and Conchie Channels and thence to the larger sponge grounds off Cape Sable.

Family JASPIDAE

Cryptotethya crypta de Laubenfels
Off East Cape Sable in Florida Bay.

Order CHORDISTIDA

Family CRANIELLIDAE

Cinachyra cavernosa Lamarck
Deeper, clear water off East and Middle Cape Sable. Occasional in Conchie Channel.

Family CHONDRILLIDAE

Chondrilla nucula Schmidt Chickenliver Sponge
Florida Bay off Cape Sable. Extends eastward to Conchie Channel and Sandy Key Basin.

GORGONIANS, STARFISH, BRITTLESTARFISH, POLYCHAETE WORMS AND BRYOZOANS

The gorgonians were identified by Robert Work, and the starfishes, brittlestarfish, polychaete worms, and bryozoans were identified by Lowell P. Thomas, both of The Marine Laboratory. The single species of chaetognath was identified by Dr. Harding Owre, and the single holothurian by the junior author.

Gorgonians were identified using Deichmann (1936). Canu and Bassler (1928) and Osburn (1914) were used for bryozoan identification. Pierce (1951) was consulted for chaetognath identification, and Hartman (1944-47 and 1945) for polychaete worms. Clark (1915, 1919, 1933) were the sources for echinoderm identification, and Deichmann (1930, 1938) were adequate for holothurian identification in the South Florida area.

Phylum COELENTERATA

Class *ANTHOZOA*

Family GORGONIIDAE

Leptogorgia virgulata (Lamarck)
One specimen collected on sandy bottom off East Cape Sable in January, 1959. OS 33

Lophogorgia punicea (Milne-Edwards and Haime)
A single dead specimen collected on the beach at East Cape Sable.

Eunicea sp.
One specimen was collected off East Cape Sable in August, 1958.

The description of this species is being prepared by F. M. Bayer of The Marine Laboratory. OS 35

Phylum BRYOZOA

Family VESICULARIIDAE

Amathia convoluta Lamouroux

Collected in Conchie Channel and Sandy Key Basin on *Thalassia testudinum* beds. OS 35

Zoobotryon verticillatum (delle Chiaje)

Common in Sandy Key Basin on *Thalassia testudinum*. OS 35

Family THALAMOPORELLIDAE

Thalamoporella gothica var. *floridana* Osburn

Common in Conchie Channel off Flamingo in coarse shell and sand bottom. Free-standing colonies eight to 15 cm in height and width collected in abundance in Conchie Channel between September, 1957, and October, 1958. Much less abundant and never so large since that time. OSR 31-37

Family SCHIZOPORELLIDAE

Stylopoma informata (Lonsdale)

Very abundant inshore on the eastern side of East Cape Sable. This species is the dominant animal in a stable community there. OSR 34-37

Phylum ECHINODERMATA

Class *ASTEROIDEA*

Family ASTROPECTINIDAE

Astropecten duplicatus Gray

Several specimens were collected on hard sand bottom off East Cape Sable in March, 1959. OS 34

Family ECHINASTERIDAE

Echinaster sentus (Say)

Most abundant in Florida Bay from Flamingo to East Cape Sable on *Thalassia testudinum* flats. OSR 31-39

Echinaster spinulosus Verrill

Common in the Clearwater Pass area of western Whitewater Bay until December, 1957. It has not been collected since. OSR 22-29

Class *OPHIUROIDEA*

Family Amphiuridae

Ophionephthys limicola Lütken
Collected in mud off East Cape Sable, August, 1958. OS 39

Ophiophragmus filograneus (Lyman)
Very common in soft mud of brackish bays, notably Coot and eastern Whitewater Bays. Uncommon in western Whitewater Bay with the exception of Mud Bay. Reached a peak in abundance during the period September through February, 1957-58 and 1958-59. Has been found only in a few samples since that time. Associated with the mollusks *Macoma mitchelli* and *Anomalocardia cunimeris*. OSR 8-24

Ophiostigma iscianthum (Say)
Collected in sponge beds off East Cape Sable, September, 1958. OS 36

Amphioplus abditus Verrill
Collected in Clearwater Pass in December, 1957, and in mud off East Cape Sable in September, 1958. Very common in the latter area. OSR 22-36

Family Ophiactidae

Ophiactis savignyi (Müller and Troschel)
In sponges off East Cape Sable, September, 1958. OS 36

Family Ophiothricidae

Ophiothrix angulata (Say)
In sponges off Cape Sable. OS 36

Family Ophiochitonidae

Ophionereis reticulata (Say)
Off East Cape Sable in coarse shell sand, November, 1958. OS 31

Family Ophiodermatidae

Ophioderma brevispinum (Say)
Very common on hard shell sand bottom off East Cape Sable. Less abundant but common on *Thalassia* flats. None found in brackish water. Three hundred twenty specimens were collected in a single five minute drag with a two meter trawl, along with 1020 specimens of *O. elegans* (see below). OSR 32-37

Family Ophiolepididae

Ophiolepis elegans Lütken
Extremely abundant on sand bottom off East Cape Sable, diminishing

in numbers toward Flamingo. One thousand twenty specimens, with disc diameters up to 12.6 mm, were collected in one five minute drag with a two meter otter trawl. OSR 22-35

Class *HOLOTHURIOIDEA*
Family HOLOTHURIIDAE

Holothuria floridana Pourtales Florida Seacucumber
Only four specimens, seven to 16 cm in length, were collected during two years of sampling. Found on the *Thalassia* flats in and around Sandy Key Basin. OSR 32-38

Phylum CHAETOGNATHA

Sagitta hispida Conant Arrowworm
Very abundant in plankton from the Shark River and western Whitewater Bay area. Almost never found in plankton taken in the Flamingo or Coot Bay areas. This arrowworm was collected once in April, 1959, in salinity of 17‰. Its normal range is apparently much higher.
OSR 17; 24-37

Phylum ANNELIDA
Class *POLYCHAETA*
Family PHYLLOCIDAE

Eteone sp.
Coot Bay, in soft mud, August, 1958. OS 15

Family NEREIDAE

Neanthes succinea (Frey and Leuckart)
Common on mangrove prop-roots in barnacle clumps. Coot and eastern Whitewater Bays. OSR 10-21

Nereis pelagica occidentalis Hartman
Taken in plankton tows from Tarpon Creek and Buttonwood Canal at opposite ends of Coot Bay. OSR 9-29

Platynereis dumerilii (Audoin and Milne-Edwards)
Mid-Whitewater Bay in mud bottom. OS 21

Nereis sp.
Buttonwood Canal at Coot Bay in plankton. Common. OSR 30-38

Family GLYCERIDAE

Glycera sp.
Florida Bay off East Cape Sable in sand. OS 38

Family Onuphidae

Onuphis magna (Andrews)
Florida Bay, off East Cape Sable, on coarse shell sand. OS 38

Family Orbiniidae

Haploscoplos sp.
Coot Bay, in mud, April, 1959. OSR 27-30

Family Ampharetidae

Melinna sp. Spaghetti Worm
Very common in Coot and eastern Whitewater Bays during the period October, 1958, through February, 1959. Only a few collected there since that date. OSR 18-28

Family Pectinariidae

Cistenides gouldii Verrill
Found in great abundance in Coot and eastern Whitewater Bays during the period October, 1958, through February, 1959. Rare in the area since that period. OSR 13-29

Family Terebellidae

Pista cristata (Müller)
Florida Bay off East Cape Sable. OS 38

Family Sabellidae

Branchioma nigromarginata (Baird)
Coot Bay, Oyster Bay and the quiet-water channels of the Shark River estuary. Attaches to shell fragments in colonies of five to 50 or more individuals, on the soft mud bottom. Scattered individuals of small size found among the oyster and barnacle clumps on the mangroves. OSR 17-32

Mollusks

The mollusks were collected during the period August, 1957, through June, 1959. Gastropods were identified by the senior author. The pelecypods were identified by Mr. Donald Moore of The Marine Laboratory. Mr. Donald S. Erdman, Lajas, Puerto Rico, provided samples of the mangrove oyster, *Crassostrea rhizophorae* Guilding, that were useful in resolving the identity of the small oysters from the mangroves in the study area. The system of taxonomic groupings and the common names given are taken from Abbott (1958). The num-

erous papers used in mollusk identification are listed in the appropriate section of the list of references.

Phylum MOLLUSCA
Class *GASTROPODA*

Family Fissurellidae (Keyhole limpets)

Diodora cayenensis Lamarck — Cayenne Keyhole Limpet
Oyster Bay and off Cape Sable on coarse broken shell gravel and sponge. Live specimens uncommon in Oyster Bay except during prolonged periods of high salinity. OSR 26-47

Diodora meta von Ihring
Oyster Bay and off East Cape Sable in coarse shell gravel and shell bars. Also collected in crevices of vase sponges. OSR 25-35

Family Trochidae (Top Shells)

Calliostoma jujubinum tampaense Conrad — Jujube Top-shell
Common off East Cape Sable and as far east as Conchie Channel and Sandy Key Basin. Occurs on hard shell sand among scattered small sponges. OSR 35-37

Tegula fasciata Born — Smooth Atlantic Tegula
Conchie Channel off Flamingo. One specimen collected. OS 34

Family Turbinidae (Turban Shells)

Turbo castaneus Gmelin — Chestnut Turban
Found only in Sandy Key Basin and on the shallow, *Thalassia* covered banks adjacent to that basin. Occurrence sporadic, colonies small to large and widely scattered. Abundance varies from year to year. They are usually fouled by slipper shells, *Crepidula convexa*. OSR 34-39

Family Littorinidae (Periwinkles)

Littorina angulifera Lamarck — Angulate Periwinkle
Wide-spread throughout the tidal areas of the mangrove zone. Found in greatest abundance in the Shark River estuary and in lesser numbers eastward toward Coot Bay.

Family Vermetidae (Worm Shells)

Vermicularia sp.
Oyster Bay and in sponges off Cape Sable. Specimens examined are said by R. Work (personal communication) to resemble intergrades between *V. knorri* and the West Indian *V. spirata* Philippi. Common at high salinity. OSR 26-37

Family Modulidae

Modulus modulus Linnaeus — Atlantic Modulus
Very abundant in *Thalassia* flats off Flamingo in Florida Bay. A thin shelled, dwarfed form occurs in Clearwater Pass, west Whitewater Bay, during prolonged dry spells with attendant high salinities in that area. Dominant gastropod of the *Thalassia* community in north Florida Bay. Fluctuates rather widely in abundance from year to year. May be heavily encrusted by small convex slipper shells, *Crepidula convexa*. OSR 26-47

Family Potamididae (Horn Shells)

Cerithidea costata da Costa — Costate Horn Shell
Oyster Bay and Clearwater Pass of west Whitewater Bay. Common. OSR 26-34

Cerithidea scalariformis Say — Ladder Horn Shell
Bear Lake and Coot Bay Pond shoreline. Not common at present but one of the most common semi-fossilized mollusks of the marl ridge north of Flamingo. Has not been observed alive since the cold winter of 1957-58. OSR 11-23

Family Cerithidae

Batillaria minima Gmelin — False Cerith
Very rare in the study area. Only five specimens collected on intertidal marl flats at Flamingo. OSR 30-47

Cerithium floridanum Mörch — Florida Cerith
Common in *Thalassia* beds off Flamingo to Sandy Key Basin. OSR 32-47

Cerithium muscarum Say — Fly-specked Cerith
Most abundant cerith in the samples from Florida Bay. A dwarfed, thin-shelled variety is found in Coot and Whitewater Bays in algae. Shows the widest range of salinity tolerance of any of the ceriths collected. OSR 14-40

Cerithium eburneum Bruguiere — Ivory Cerith
Common on Florida Bay *Thalassia* flats. OSR 35-40

Cerithium algicola C. B. Adams — Middle-spined Cerith
Rare in the Cape Sable region. One living specimen found in August, 1958, in a *Thalassia* collection taken off Flamingo. OS 32

Bittium varium Pfeiffer — Variable Bittium
Common in Coot Bay and Clearwater Pass of Whitewater Bay in algae

and the marine grass, *Diplanthera*, during periods of high salinity. OSR 12-32

Family Epitoniidae (Wentletraps)

Epitonium sp.
One recently dead specimen taken in Conchie Channel off East Cape Sable in April, 1958.

Family Calyptraeidae (Cup-and-saucers)

Calyptraea centralis Conrad — Circular Cup-and-saucer
Off East Cape Sable in firm shell sand. A live specimen collected in October and another in November, 1958. OSR 28-31

Crepidula convexa Say — Convex Slipper Shell
Oyster Bay, in western Whitewater Bay during periods of high salinity. Common to very abundant, occupying all living shell surfaces at times, in the *Thalassia* flats of Florida Bay. During periods of maximum abundance, individuals may attain only five to seven millimeters in length at full sexual maturity. Under good growing conditions sexually mature animals may average 20 mm. Most abundant when salinities average 30‰ or higher. Some individuals gravid throughout the period April through November with heaviest spawning in September and October. OSR 21-37

Crepidula aculeata Gmelin — Spiny Slipper-shell
Found only as worn beach specimens on East and Middle Cape Sable.

Crepidula plana Say — Eastern White Slipper-shell
Oyster Bay and off Cape Sable where there are coarse shell fragments and whole animals. Found mainly within the apertures of dead gastropods. Gravid specimens found only during September and October, 1958. OSR 35-37

Family Strombidae

Strombus alatus Gmelin — Florida Fighting Conch
Found occasionally as bleached, worn beach specimens on Cape Sable. No freshly dead or living specimens collected although they are reported by commercial fishermen, to occur in the commercial sponge grounds off the Shark River.

Family Eratoidae

Erato maugeriae Gray — Mauger's Erato
Three living specimens collected during sampling of the hard shell sand bottoms off Middle Cape Sable in September, 1958. OS 35

Trivia candidula Gaskoin — Little White Trivia
A single living specimen collected off East Cape Sable in September, 1958, on firm shell sand. Depth 10 feet. OS 35

Family Naticidae

Polinices duplicatus Say — Shark Eye
Three living specimens 12 to 30 mm taken on intertidal marl flats at Flamingo in Florida Bay. OSR 24-37

Natica canrena Linnaeus — Colorful Atlantic Natica
Clearwater Pass in Whitewater Bay. Two live specimens found in December, 1957, following a severe cold wave. Only dead shells found since that time. Rare. OS 22

Family Cassididae

Phalium granulatum Born — Scotch Bonnet
Represented by a single badly eroded beach specimen taken on East Cape Sable.

Family Ficidae

Ficus communis Röding — Common Fig Shell
No living specimen was collected during this survey. Twice, however, during northwest storms in the winter of 1958-59, large quantities of fig shells washed ashore on Cape Sable beaches. These shells were recently dead, and intact in spite of their fragile nature and the pounding they took in the surf. They must occur in abundance in the off-shore areas to the north and west of Cape Sable.

Family Muricidae

Murex recurvirostris rubidus F. C. Baker — Rose Murex
Small individuals occasionally found alive on hard sand bottom off Cape Sable and in Conchie Channel. No living adult collected. Smallest specimens in Conchie Channel between Murray and Sandy Keys and size of specimens increases as one collects westward toward Cape Sable. OSR 32-40

Murex pomum Gmelin — Apple Murex
Apparently rare in the study area. Two small specimens taken by trap in 12 feet of water off East Cape Sable. Bottom material firm shell sand and sponge fragments. OS 34

Murex florifer Reeve — Lace Murex
The most common murex of the study area, found only in Florida Bay, not in the brackish waters of Coot and Whitewater Bays. Juveniles

taken in Joe Kemp Channel but adults never were collected there. Size of specimens increases as one collects westward toward Cape Sable and full adults are common on the sponge beds on coarse shell gravel and shell sand. Easily trapped. OSR 30-38

Murex cellulosus Conrad Pitted Murex

Uncommon in collections from Florida Bay in the Conchie Channel-Cape Sable area. Probably rather common in the sponge beds further west and south as those collected were found in crevices in sponges. Five living specimens were collected during two years of collecting. Dead shells are found in many hauls of shell from Conchie Channel. No evidence is available that they enter Whitewater Bay brackish waters. OSR 30-37

Cantharus multangulus philippi

Muricopsis ostrearum Conrad Mauve-mouth Drill

Shows be un Buccin dae p 575

Common though not abundant member of the turtle grass, *Thalassia testudinum*, community. Nearly always heavily covered by small red and brown algae. OSR 31-37

Urosalpinx tampaensis Conrad Tampa Drill

Clearwater Pass area of Whitewater Bay. The species was common in that area from the beginning of the study in July, 1957, until the cold periods of the following winter. The impact of the cold weather may have been a factor in their disappearance but it is suspected that the severe reductions in salinity beginning in January, 1958, had a greater effect since the species was re-discovered as 2-5 mm young during a marked rise in salinity to 32-35 ‰ in May, 1959. At the onset of lower salinity values resulting from heavy rainfall in June, 1959, these young soon died. OSR 22-35

Eupleura sulcidentata Dall Sharp-ribbed Drill

Western Whitewater Bay and Florida Bay from Cape Sable to Joe Kemp Key during 1957 and 1958. Diminished greatly in numbers in Florida Bay during 1959 and disappeared completely from western Whitewater Bay in the spring of 1959. Most abundant in shell gravel and marl mud mixture of tidal channels. Color of specimens variable, mostly shades of gray, brown or pink with narrow bands of darker color. OSR 30-37

Family COLUMBELLIDAE (Dove Shells)

Columbella mercatoria Linnaeus Common Dove Shell

Turtle grass flats in Florida Bay. Not in Whitewater Bay or in Snake Bight *Diplanthera* flats. Three specimens taken in July, 1958. Uncommon. OSR 29-37

Columbella rusticoides Heilprin — Rusty Dove Shell
Common on turtle grass flats of Florida Bay in high salinities Associate with *Modulus modulus* and *Cerithium eburneum*. Brown periostracum and normal coating of small algae and bryozoans make this a difficult mollusk to see in its undisturbed habitat on the blades of *Thalassia*. OSR 28-45

Anachis avara Say — Greedy Dove Shell
Common on the blades of *Thalassia* and in bunched algae of high salinity areas of Florida Bay. A dominant member of the *Thalassia* community. Not taken in brackish water. OSR 30-47

Anachis obesa C. B. Adams — Fat Dove Shell
Collected on *Thalassia* flats but appears to prefer deeper water than the preceeding species and is occasionally collected on shell gravel bottom of the tidal scour channels off East Cape Sable. OSR 28-47

Anachis translirata Ravenel — Well-ribbed Dove Shell
Florida Bay off East Cape Sable. Found most often in deeper water

FIGURE 2. Average condition of size, spination and color (center shell) and extremes of smoothness, spination and size in adults (right and left hand shells) from the inter-tidal population of *Melongena corona* from Flamingo on Florida Bay.

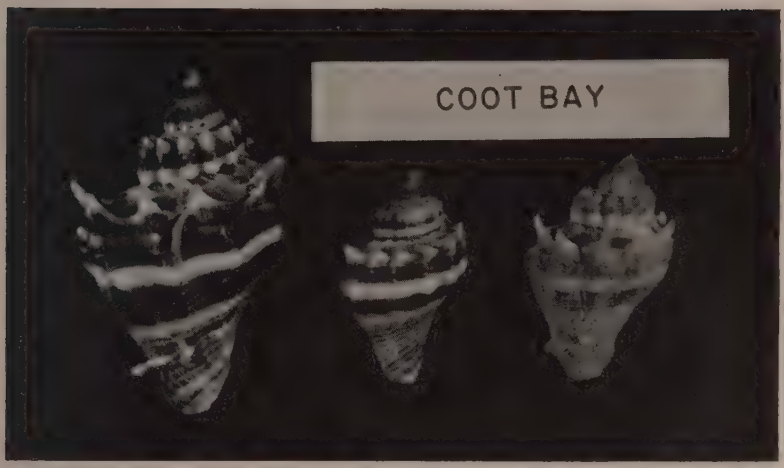

FIGURE 3. Average condition of size, spination and color (center shell) and extremes of coloration, size and spination among adults from the sub-tidal population of *Melongena corona* (right and left hand shells) from Coot Bay and Coot Bay Pond.

on coarse shell. Also found in *Thalassia* although this species does not appear to be restricted to the *Thalassia* community. OSR 32-37

Family BUCCINIDAE

Cantharus tinctus Conrad Tinted Cantharus

Clearwater Pass and Oyster Bay of western Whitewater Bay, Florida Bay in Sandy Key Basin, Conchie Channel and off East Cape Sable. This is another example of a species that was common in Whitewater Bay prior to the cold winter of 1957-58 which was accompanied by a severe reduction in salinity. Has not been collected since May, 1959. Less common in Florida Bay since that time. OSR 18; 25-37

Family MELONGENIDAE

Melongena corona Gmelin Crown Conch

Oyster Bay, eastern Whitewater Bay, Coot Bay and Coot Bay Pond, and on intertidal marl flats at Flamingo in Florida Bay. One of the most interesting mollusks of the survey area. Most abundant on the intertidal mud flats at Flamingo. These are the only specimens in the survey area that live in the intertidal zone. In all other areas they are sub-tidal or only rarely exposed during extreme low water caused by

FIGURE 4. Average condition of size, spination and color (center shell) and extremes of those conditions (right and left hand shells) from the sub-tidal population of *Melongena corona* from the mouth of the East River in eastern Whitewater Bay. This is an area of lowest average salinity at which the species was found.

wind evacuation during minus tide periods. The Flamingo population undergoes wide changes in environment from extreme heat of summer to severe cold during infrequent winter cold waves. Salinity changes at Flamingo are wide and sometimes sudden, particularly if the animals are exposed by low tides during periods of heavy rainfall. The Flamingo population conforms most closely to the form or variety, *M. corona altispira* Pilsbry (Figure 2). In Coot and eastern Whitewater Bay, on the other hand, where salinities are normally lower and where the animals are never exposed to intertidal vagaries in the environment, the shells are broader, darker, have a thinner periostracum and greater spines. These animals, although less than five miles from the Flamingo population, are more nearly like the form *M. corona*. Typically the Coot Bay and east Whitewater Bay specimens have one row

cf shoulder spines and occasionally a second row of tubercles (Figures 3-4). A third variation is to be found in Oyster Bay, western Whitewater Bay, where the average size is much greater than at either of the two preceding areas. In Oyster Bay the shells are massive and heavily spined with as many as two rows of well developed shoulder spines and two rows of basal spines or tubercles (Figure 5). These specimens most closely resemble *M. corona perspinosa* Pilsbry. In Oyster Bay, *M. corona* lives on a reef of oysters, *Crassostrea virginica*. The Flamingo population of *Melongena* feeds largely on three species of bivalves, *Tellina promera, Tellina similis* and the paper mussel, *Amygdalum papyria*. The Coot Bay and Coot Bay Pond specimens feed on *Anomalocardia cunimeris, Macoma mitchili* and *Tellina tampaensis*. Probably they also feed on dead or diseased oysters as they do so in Oyster Bay and other oyster bar associations throughout their range. Observations on the Oyster Bay population have shown that the large specimens living there feed mainly on oysters infested by polyclad flat-worms, and on the bivalves *Abra aequalis* and *Tellina tampaensis*. The Flamingo marl flat population spends much of its time partially

FIGURE 5. Average condition of size, spine development and coloration (center shell) and extremes of these conditions (right and left hand shells) from the oyster bar population of *Melongena corona* of Oyster Bay, western Whitewater Bay, near the Shark River estuary.

or wholly buried to avoid desiccation and heat during low water periods. Many of them when lifted from the mud were found to have their proboscises fully extended and inserted in a tellin or other prey animal. Spawning for all three populations takes place throughout the period March through October with a peak in April, May and June. Growth of crown conchs is slow. The average size of specimens from Flamingo is about 7 to 10 cm. Occasionally giants are found however that are similar to all the rest except in size. One such giant was collected by Dr. Gilbert L. Voss from Lake Ingraham back of Cape Sable. It measured 17.1 cm in length and 9.8 cm in width at the base of the spines on the shoulder (Figure 6). No explanation of the freakish size of this and a few other specimens from Flamingo can be given.

OSR 0; 9-39; 45

Busycon contrarium Conrad — Lightning Whelk

Florida Bay off Cape Sable. No adults have been taken in the survey area although many shells of dead adults are found on the mud flats

FIGURE 6. Comparison of a giant specimen of *Melongena corona* from Lake Ingraham on Cape Sable with a specimen of normal maximum size from the intertidal mud-flat population at Flamingo. The giant shell measures 171 mm in greatest length and 98 mm in greatest width.

being utilized by hermit crabs. Strings of egg capsules are rather common on Cape Sable Beaches. Young specimens 5-15 mm in length are common in the coarse shell deposits of Conchie Channel and either move to the west and deeper water as they grow, or die as no intermediate size has been taken. Not collected in Coot or Whitewater Bays. OSR 32-37

Busycon spiratum Lamarck Pear Whelk
Oyster and Florida Bays. As with *B. contrarium* only the very young stages were found alive in the study area. Dead shells of adults and newly deposited egg strings are common on the beaches at Cape Sable. OSR 26; 30-37

Family Nassariidae

Nassarius vibex Say Common Eastern Nassa
All stations in Whitewater and Coot Bays and on the soft mud flats along shore in Florida Bay. Most abundant in brackish water but can tolerate salinity values to 40 ‰. Abundant in *Diplanthera* and *Ruppia* of Coot Bay. Variable in size and coloration from area to area. Largely replaced in Florida Bay, especially in deeper water, by the following species. *N. vibex* is a mud dwelling species while the following species is most abundant in shell gravel and sand deposits or on the firm marl along the margins of *Thalassia* flats. OSR 9-30; 40

Nassarius ambiguus Pultney Variable Nassa
Never as abundant as the preceeding species. A sand rather than mud dweller. OSR 32-37

Family Fasciolariidae

Fasciolaria tulipa Linnaeus True Tulip
Florida Bay. An uncommon member of the *Thalassia* community. Two small specimens and several masses of egg capsules taken in October, 1958, and February, 1959. Large shells occupied by hermit crabs are occasionally found on the intertidal marl flats at Flamingo. All living specimens were of the black color phase. OSR 28-37

Fasciolaria hunteria Perry Banded Tulip
One specimen 32 mm long collected alive in *Thalassia* of Joe Kemp Channel in March, 1958. Rare. OS 40

Pleuroploca gigantea Kiener Florida Horse Conch
Florida Bay from Flamingo to Middle Cape Sable and beyond. Only young stages collected, to 40 mm in length. Strings of egg capsules containing viable eggs collected on Cape Sable beaches during periods

of strong west to southwest winds. This may explain why the young stages only of species having "crawl-away" larvae are found so often in the Conchie Channel-Sandy Key Basin area. It would be interesting to find whether the eggs in capsule are better able to tolerate harsh environments than the adults hence may survive marginal habitats not used by the adults. Observed salinity range for young stages only.
OSR 34-40

Family Olividae

Olivella sp.
One live specimen taken by *van Veen* grab on hard shell sand bottom off East Cape Sable in March, 1959. OS 35

Family Marginellidae

Prunum apicinum Menke Common Atlantic Marginella
All stations in Whitewater and Coot Bays. Florida Bay on shallow flats. A member of the *Diplanthera* and *Thalassia* communities.
OSR 6; 15-30; 40

Family Conidae (Cone Shells)

Conus floridanus Gabb Florida Cone
Two dead shells, 25 to 35 mm in length, found in beach drift on East Cape Sable.

Conus stearnsi Conrad Stearn's Cone
Florida Bay on firm shell sand and gravel in the deeper parts of Joe Kemp and Conchie Channels. Abundant off Cape Sable. Most abundant in the area during the period September, 1957, through March, 1959. Since the latter date salinities have fluctuated markedly and turbidities have increased so that living specimens have become uncommon. May be only a variety of *C. jaspideus*. OSR 32-40

Conus jaspideus Gmelin Jasper Cone
Florida Bay from shelly bottom. Often found in sponges in the beds off Cape Sable and in Conchie Channel. Has largely vanished from samples taken after March, 1959, probably as a result of the great increases in turbidity that have taken place in this area concurrent with wider than normal salinity fluctuations and consequent dying back of *Thalassia*. OSR 33-38

Family Terebridae

Terebra dislocata Say Common Atlantic Auger
Off East Cape Sable in soft mud bottom. A single live specimen taken

on September 10, 1958. Common in quartz sand off Marco Beach in Collier County to the northwest. OS 34

Family Turridae

Crassispira ebenina Dall — Dall's Black Turret
Common member of the Thalassia community of Florida Bay. OSR 28-47

Crassispira ostrearum Stearns — Oyster Turret
Same as for the preceeding species. OSR 30-38

Cerodrillia perryae Bartsch and Rehder — Perry's Drillia
Common though not abundant in the *Thalassia* community. OSR 30-38

Cerodrillia thea Dall — Thea Drillia
Common in *Thalassia* community. OSR 30-40

Monilispira albinodata Reeve — White Banded Drillia
Florida Bay in *Thalassia*. Not as common as the preceeding four species. Also found at times in Oyster Bay following prolonged (two to three months) high salinity. OSR 28-40

Family Bullidae

Bulla striata Bruguière — Striate Bubble
Eastern Whitewater Bay until February, 1958. Also found in *Thalassia* flats of Florida Bay near Joe Kemp Channel. Florida Bay specimens larger and heavier than those collected in Whitewater Bay. The Whitewater Bay specimens were exceedingly slimy and very dark brown just prior to their extinction. This was probably brought about by low salinities. Recurrent in Whitewater Bay when salinities rise to 20 ‰ and higher. OSR 12; 18-37

Family Atydae

Atys caribaea Orbigny — Caribbean Paper-bubble
Coot and eastern Whitewater Bays and in soft marl mud, rich in organics, along the Florida Bay shore from Snake Bight to East Cape Sable. Uncommon. OSR 12-26

Haminoea elegans Gray — Elegant Paper-bubble
Coot Bay. Numerous during the first few months of the study, July through December, 1957, but in greatly diminished numbers after the opening of the Buttonwood Canal to Flamingo. OSR 18-27

Haminoea succinea Conrad
Coot and eastern Whitewater Bays until January, 1958. OSR 11-32

Haminoea antillarum Orbigny Antillean Paper-bubble
Oyster, Coot and Florida Bays in quiet shallows. Found most abundantly in mud rich in organic material and usually associated with *Ruppia* and *Diplanthera.* OSR 18-37

Family Aplysidae

Bursatella leachi plei Rang Ragged Sea Hare
Oyster Bay near the Shark River estuary where it was collected in large samples during December, 1957. This species has not been collected since in spite of repeated collecting in that area. On muddy shell gravel with red algae. OSR 28-33

Family Pleurobranchidae

Pleurobranchus atlanticus Abbott Atlantic pleurobranch
Oyster Bay on December 17, 1957, with a large collection of ragged sea hares. This is the only specimen taken in two years of collecting. OS 28

Family Ellobiidae

Melampus coffeus Linnaeus Mangrove Coffee Snail
Flamingo, Coot Bay Pond and the Shark River estuarine area. This pulmonate most abundant and reaches the greatest average size on the wet marl marsh north of the marina at Flamingo. Large numbers of 2 to 7 mm young found in the upper intertidal zone among red and black mangroves at the Florida Bay entrance to the Buttonwood Canal during February and March, 1959. Successful reproduction by large adults living in the drier portions of the marl prairie region is uncommon, and dependent upon periodic flooding by abnormally high tides. During the drought periods these adults congregate in densely packed masses under driftwood and enter a state of semi-dormancy. Spawning of these large individuals was observed only once, during July, 1960, at which time gelatinous egg masses were deposited on the moist under surfaces of wood fragments. Populations living in the intertidal zone move up and down the pneumatophores of the black mangrove to keep above the rising tide. Spawning is most successful and young most abundant in mangrove swamps that are adjacent to higher ground having an abundance of decomposing vegetation. *Melampus coffeus* feeds by skeletonizing mangrove leaves.

Family Ischnochitonidae

Chaetopleura apiculata Say Common Eastern Chiton
Oyster Bay and Florida Bay off Cape Sable. On large shell fragments

in the former area and on sponges in Florida Bay. This small chiton is apt to be overlooked because of its drab coloration and ability to fit tightly against irregular surfaces. Abundant on the shelly bottom off Cape Sable. OSR 26-37

Class *SCAPHOPODA*
Family DENTALIDAE

Dentalium antillarum Orbigny Antillean Tusk
One specimen taken in an exploratory *van Veen* grab collection made 100 yards off the beach at East Cape Sable in September, 1958. OS 34

Dentalium pilsbryi Rehder Pilsbry's Tusk
One specimen taken with the preceeding species off East Cape Sable in September, 1958. OS 34

Class *PELECYPODA*
Family ARCIDAE (Ark shells)

Arcopsis adamsi E. A. Smith Adams' Miniature Ark
Western Whitewater Bay on rock and coarse shell bottom. A single living specimen collected October 17, 1958.

Anadara notabilis Röding Eared Ark
A single live specimen taken on soft mud bottom off Cape Sable on September 10, 1958.

Noetia ponderosa Say Ponderous Ark
Three specimens collected on sandy mud bottom one-fourth mile off Cape Sable on September 10, 1958.

Family GLYCYMERIDAE (Bittersweets)

Glycymeris pectinata Gmelin Comb Bittersweet
One living specimen taken off East Cape Sable on hard shell bottom in September, 1958.

Famly MYTILIDAE (Mussels)

Brachidontes exustus Linnaeus Scorched Mussel
All stations in eastern Whitewater Bay and in Coot Bay. Found attached to basal portion of the algae *Batophora oerstedi, Acetabularia crenulata,* and *Udotea wilsoni*. The most abundant sessile bivalve in the brackish algal growth. OSR 9-32

Brachidontes recurvus Rafinesque Hooked Mussel
Intertidal among oysters on mangrove roots; along rocky sections of shoreline and in the *Balanus eburneus* community of Coot and White-

water Bays. Least abundant when with barnacles. Reaches its greatest size in the Shark River Estuary. OSR 4-35

Amygdalum papyria Conrad Paper Mussel
Found in soft marl deposits of Oyster Bay, Coot Bay and on the intertidal mud flats off Flamingo in Florida Bay. It rests in a tightly woven "sock" formed of its own byssal threads, in a vertical posture, with just the edges of the larger, posterior portion of the shell showing above the mud surface. Counts of individuals on the bare marl flats off Flamingo run as high as 1,700 individuals per square meter of mud surface. OSR 14-32

Musculus lateralis Say Lateral Musculus
Florida Bay in Joe Kemp Channel off Flamingo. Live specimens taken only in October, 1958.

Family Pteriidae (Wing Oysters)

Pteria colymbus Röding Atlantic Wing Oyster
Only one specimen taken alive on *Thalassia* flats adjoining Conchie Channel on October 27, 1958. Uncommon in beach drift at East Cape Sable.

Family Pinnidae (Pen Shells)

Pinna carnea Gmelin Amber Pen Shell
A single dead specimen still containing some of the adductor muscle was taken on East Cape Sable following a severe winter storm in January, 1958.

Atrina rigida Solander Stiff Pen Shell
Numerous individuals of this and the following species have been found washed up on the beaches of East and Middle Cape Sable following winter storms. In many instances, the animals were still alive several hours after the passage of the storm, indicating the ability to tolerate drying conditions for some time without dying. A common animal of the firm marl bottoms off Cape Sable.

Atrina serrata Sowerby Saw-toothed Pen Shell
Florida Bay off Cape Sable in shelly marl mud. Often taken alive in beach drift after winter storms.

Family Pectinidae (Scallops)

Pecten ziczac Linnaeus Zigzag Scallop
One living specimen 22 mm in length, taken by *van Veen* bottom grab on hard-packed shell bottom of the sponge beds two miles south of Middle Cape Sable.

Aequipecten muscosus Wood — Rough Scallop
Observed only rarely as eroded single valves on the beach at Middle and East Cape Sable.

Aequipecten irradians Lamarck — Atlantic Bay Scallop
Western Whitewater Bay only as juveniles under 30 mm in length. Adults sometimes abundant in Sandy Key Basin and the clear waters south of Flamingo. Juveniles found in greatest numbers during the period January through March. Peak spawning period September through December. OSR 18-41

Pecten gibbus Linnaeus — Calico Scallop
Found occasionally as single valves on the beaches of East and Middle Cape Sable following winter storms.

Family Limidae

Lima pellucida C. B. Adams — Antillean Scallop
Three specimens found in the study area at Oyster Bay, Clearwater Pass in western Whitewater Bay and one-half mile south of East Cape Sable. The two specimens collected from Oyster and Whitewater Bays were taken prior to the pronounced cold and drop in average salinity values that occurred in December, 1957, and February, 1958.

Family Anomiidae (Jingle Shells)

Anomia simplex Orbigny — Common Jingle Shell
Deeper water of Florida Bay. Uncommon in the survey area as shown by the virtual absence on Cape Sable beaches of this species while it is extremely abundant in the Marco Beach area of Collier County a few miles to the northwest. One gravid adult collected in Conchie Channel, Florida Bay, in February, 1959.

Famly Ostreidae (Oysters)

Ostrea equestris Say — Crested Oyster
Florida Bay in all areas having near-normal sea salinities. Not taken alive in the brackish bays or estuaries. One of the common animals found attached to the Bay scallop, *Acquipecten irradians*.

Crassostrea virginica Gmelin — Eastern Oyster
Shark River, southern Whitewater Bay and Coot Bay. The dominant intertidal mollusk of the Shark River mangrove complex. A few dead and dying reefs of considerable size in Oyster Bay suggest that conditions were more favorable in the past for oyster settlement and growth than is now the case. Oyster clumps on the stilt roots of the

red mangrove provide substratum for a distinctive community of plants and animals. The presence of bands of dead shells on the mangroves of northern and eastern Whitewater Bay suggest that extensive colonization occasionally takes place during periods of high salinity only to be reduced by the normally low salinities common to that area during periods of heavy rainfall. OSR 7-36

Family Carditidae

Cardita floridana Conrad Broad-ribbed Cardita
Oyster Bay, western Whitewater Bay and vegetated flats in Florida Bay. The dominant bivalve of the *Thalassia* epi-faunal complex. It is found most often, attached by byssal threads, to the basal portion of the plants. It enters western Whitewater Bay during periods of high salinity. Settlement occurs at the low end of the following range of salinity but mortality is apparently total following settlement until salinities reach 25‰ or higher.

Venericardia tridentata Say Three-toothed Cardita
A single specimen collected on September 10, 1958, from fine shell sand bottom one mile south of Middle Cape Sable.

Family Dreissenidae

Congeria leucophaeata Conrad Conrad's False Mussel
Taken the year around in the fresh to brackish water at the mouths of larger rivers emptying into the northern shore of Whitewater Bay. Also found abundantly at Coot Bay Pond during periods of heavy fresh-water runoff from the mainland. Reaches a peak of abundance during the period September through December. Grows to the greatest size in the rich waters of Coot Bay Pond but is most abundant in the northern perimeter of Whitewater Bay. OSR 0-15

Family Lucinidae (Lucinas)

Lucina amiantus Dall Lovely Miniature Lucina
Florida Bay off Cape Sable. One living specimen taken in September, 1958.

Phacoides pectinatus Gmelin Thick Lucina
Moderately common in muddy bottom of Oyster Bay.

Phacoides nassula Conrad Woven Lucina
Living specimens common in soft mud bottom of Whitewater Bay at Clearwater Pass and in Oyster Bay during the period August, 1957, through June, 1958. No living specimen taken there after the latter date. Common in soft marl mud of Joe Kemp Channel. OSR 23-24

Codakia orbiculata Montagu Dwarf Tiger Lucina
Western Whitetwater Bay in firm marl bottom, and in Florida Bay on the *Thalassia* flats. Common. OSR 18-35

Family Cardiidae (Cockles)

Trachycardium muricatum Linnaeus Yellow Cockle
Uncommon in western Whitewater Bay and in sandy bottom off Cape Sable.

Trachycardium egmontianum Shuttleworth Prickly Cockle
Florida Bay off Middle Cape Sable in fine shell sand. Uncommon.

Laevicardium mortoni Conrad Morton's Egg Cockle
During the first few months of the study in 1957, this mollusk was found abundantly throughout Coot, Whitewater and Oyster Bays and in the *Diplanthera* beds off-shore in Snake Bight. The population was destroyed by the cold weather and low salinities of the winter of 1957-58. Re-colonization of western Whitewater Bay was observed in June and July of 1958. These newly settled individuals reached an average length of 7 mm before they were again destroyed. Salinities at the time of the second kill averaged 11‰. OSR 11-36

Family Veneridae (Venus Clams)

Chione cancellata Linnaeus Cross-barred Venus
The dominant, large bivalve of the Florida Bay *Thalassia* and shell sand bottoms. In the shell sand bottom the species is compact, obese, more solid and with low cancellations lacking the leaf-like projections of specimens found growing in the soft marl substrate of the *Thalassia* beds. It invades Oyster and western Whitewater Bays during periods of high salinity. No adults have been found in the latter areas. OSR 18-38

Anomalocardia cunimeris Conrad Pointed Venus
The dominant bivalve of the *Diplanthera-Ruppia* community of Coot Bay. Fluctuates greatly in numbers. Most abundant in the latter half of 1957 and the first half of 1958 when samples of measured square meters of bottom in Coot Bay produced counts in excess of 1,000 individuals. In late winter of 1959, counts per square meter had dropped to 200. This species has invaded most of the brackish areas at one time or another as evidenced by rich shell remains. It lies in the upper two cm of bottom detritus in close association with *Macoma mitchili*. During periods of very low salinity in the estuarine areas, the pointed clams are decimated; however, colonies in isolated

locations at the mouths of estuaries remain to recolonize the dead bottoms. Studies on the fauna of the hypersaline lagoons of the northwestern Gulf of Mexico indicate that this species can tolerate extremely high salinities. This study indicates that they are adversely affected by salinities below 12‰. OSR 12-32

Pitar simpsoni Dall Simpson's Venus
A single living specimen taken in western Whitewater Bay during December, 1957.

Macrocallista nimbosa Solander Sunray Venus
Uncommon in beach drift on Cape Sable.

Macrocallista maculata Linnaeus
Uncommon in beach drift on Middle Cape Sable.

Dosina elegans Conrad Elegant Dosina
Moderately common in beach drift at Cape Sable. No living specimens collected from inshore waters.

Family TELLINIDAE (Tellins)

Tellina versicolor DeKay DeKay's Dwarf Tellin
Florida Bay off Cape Sable in fine, muddy sand. Uncommon in collections.

Tellina promera Dall Promera Tellin
Florida Bay and western Whitewater Bay. Dominant tellin of the soft marl muds of Florida Bay *Thalassia* flats. Common in all muddy areas having high salinity. OSR 25-39

Tellina tampaensis Conrad Tampa Tellin
Oyster Bay, western Whitewater Bay, Coot Bay and brackish-water areas along shore in Florida Bay. One of the common mollusks of brackish areas. May be confused with *Abra aequalis*. OSR 15-30

Tellina similis Sowerby Candy Stick Tellin
A very common tellin found in Florida Bay from Joe Kemp Key westward to East Cape Sable and beyond. Found most commonly in muddy sand of the *Thalassia* flats and in the intertidal marl flats. Color variations are common, with the most vivid forms coming from clear, deeper water with high shell sand mixture in bottom deposits.

Tellina lineata Turton Rose Petal Tellin
Occasional in Oyster Bay. One living specimen taken in October, 1958, and one in September, 1960. Dominant in the marl intertidal flats just off Flamingo in Florida Bay.

Tellina alternata Say — Alternate Tellin
Oyster Bay, Coot Bay (infrequent) and Florida Bay off Flamingo in soft sandy muds. This is the common large tellin of the study area. OSR 28-37

Tellina punicea Born
This bright pink, solid tellin is a common inhabitant of the fine sandy mud bottom of the sponge grounds off Cape Sable. Live specimens and paired dead valves are often washed ashore in quantity on Cape Sable beaches after on-shore storms. OSR 28-37

Tellidora cristata Recluz — White Crested Tellin
Florida Bay in soft marl mud off East Cape Sable. Two specimens 22 and 26 mm in length were collected by van Veen grab in September, 1958.

Macoma mitchili Dall
Whitewater, Coot and Florida Bays. This is the most abundant of the tellins of the brackish-water areas and occurs in some localities in practically pure culture. Found in greatest abundance during the period June, 1958, through February, 1959, in Whitewater Bay at the mouth of the East River. Salinities at that time ranged between 5 and 11‰. Spawning occurs during May, June and July. Growth is rapid, with adult size (18-22 mm shell length) attained in three months. Adults assume a strong pink blush at spawning time and die immediately following spawning. Almost total mortality was observed when average salinity values fell below 5‰. OSR 4-37

Macoma constricta Bruguiere — Constricted Macoma
A single fresh valve found in Oyster Bay in October, 1958.

Family Semelidae

Semele proficua Pultney — White Atlantic Semele
Dead shells abundant in all deeper areas having marl mud bottoms. Occasionally found as paired, fresh valves on Cape Sable beaches. Common in Oyster Bay during prolonged periods of high salinity.

Abra aequalis Say — Common Atlantic Abra
One of the most abundant tellin-like inhabitants of the marl banks of Florida Bay off Flamingo. It is particularly common in the root mats of *Thalassia*. Also found during periods of high salinity in Coot and western Whitewater Bays.

Family Sanguinolariidae

Tagelus plebius Solander — Stout Tagelus
Inhabitants of the firm marl banks of Florida Bay. It invades Coot

Bay and Oyster Bay during periods of high salinity. The species was collected in Coot Bay during the period July, 1957, through February, 1958. Only dead shell taken since that time. Probably not common anywhere in the area as the shells are seldom seen on the beaches, and make up only a minute fraction of the shell fragments examined from the bottom deposits. OSR 20-35

Tagelus divisus Spengler — Purplish Tagelus

More abundant than the preceding species in Florida Bay. Not found in Coot Bay. Apparently prefers sandier substrate than *T. plebius*. Collected most often in 6 to 10 feet of water off Middle and East Cape Sable.

Family Mactridae

Spisula solidissima Dillwyn — Atlantic Surf Clam

A single living specimen taken by van Veen grab off Middle Cape Sable in September, 1958. Occasional in beach drift on Cape Sable.

Labiosa plicatella Lamarck — Channeled Duck Clam

Commonly washed ashore on the beaches of Cape Sable. No living specimens were collected.

Mactra fragilis Gmelin — Fragile Atlantic Mactra

Two living specimens collected by van Veen grab in muddy bottom off East Cape Sable in September, 1958. This is one of the common species on the beaches at Cape Sable and is an inhabitant of the deeper waters west of the survey area. Small individuals less than 10 mm in length occur in the marl banks in the Flamingo vicinity but extensive collecting failed to produce the larger adults.

Family Corbiculiidae

Polymesoda caroliniana Bosc — Carolina Marsh Clam

A single valve 36 mm in length and 32 mm in height, and with the periostracum intact, was collected at the mouth of East River in eastern Whitewater Bay in July, 1958.

Family Corbulidae

Corbula contracta Say — Contracted Corbula

Common in the fine, hard-packed shell sands of the current scoured channels off Cape Sable. Taken in van Veen grab samples in September and October, 1958.

Corbula barrattiana C. B. Adams — Barratt's Corbula

From the quiet and moderately clear waters of the sponge grounds off

Cape Sable. Variable in color from white, to yellow and flesh pink. Occurs in much less compact bottom than does the preceeding species.

Corbula swiftiana C. B. Adams

Rare in collections. Taken on hard shell sand bottom two miles south of Middle Cape Sable.

Family Pholadidae

Cyrtopleura costata Linnaeus — Angel Wing

Apparently rare in the survey area. Only badly eroded single valves occur in beach drift on Cape Sable. One living specimen 31 mm in length was collected in soft, sandy mud in Oyster Bay on October 17, 1958.

Family Lyonsiidae

Lyonsia hyalina Conrad — Glassy Lyonsia

Occasionally abundant in Coot Bay and on the marl flats off Flamingo in Florida Bay. Were collected in Coot Bay only after the opening of the Coot Bay-Flamingo Canal. OSR 26-39

Family Loliginidae

Lolliguncula brevis Blainville — Brief Squid

Thirty-one brief squid 2.5 to 15 cm in length were collected during 1957-59. Twenty-three of these were taken in Conchie Channel, six in Joe Kemp Channel and two in Oyster Bay. Taken during the months of October through May, the period of annual highest salinity. Found by Gunter (1950) in salinity as low as 17.7‰. OSR 22-38 OTR 17-24

Crustaceans

Wass' recent remarks (1955) on the lack of organized information on the decapod crustaceans of the northeastern Gulf of Mexico applies equally well to other portions of the peninsula, particularly the uninhabited southwestern tip. Until the beginning of the present ecological survey of north Florida Bay and adjacent estuarine areas, no extensive collections or detailed studies were carried out on the macroscopic marine and estuarine crustaceans in the area. Davis (1948, 1950) and Davis and Williams (1950) reported on plankton samples taken in the West Lake-Cuthbert Lake-Lungs region to the east, but did not include macroscopic crustaceans. Rathbun, in her series of monographs of American crabs (1918, 1925, 1930, 1937), occasionally listed material from Florida Bay. Holthuis, in his report

on the American palaemonid shrimps (1951, 1952), listed various specimens from within the boundaries of Everglades National Park. Wass' (1955) report on the decapod crustaceans of Alligator Harbor, Florida, and the work of Hay and Shore (1918) on the decapods of Beaufort are the only complete crustacean faunal studies available for localities in the southeastern United States.

The material herein reported was collected mainly by otter trawl, supplemented by dipnet, plankton nets, and hand collections. Salinity observations were made whenever possible at the collecting stations.

The material was largely identified by the junior author. Thanks are due Dr. Fenner A. Chace, Jr., Curator, Division of Marine Invertebrates, U. S. National Museum, for helpful comments on some systematic problems and to Dr. Gilbert L. Voss of The Marine Laboratory for confirmation of identifications.

Class *CRUSTACEA*
Subclass COPEPODA

No copepod was identified during the course of the present study. However, Davis (1948) lists three species, *Pseudodiaptomus coronatus* Williams, *Acartia floridana* Davis, and *Cyclops panamensis tannica* Davis, from West Lake. Observed salinity 15.39‰.

Subclass CIRRIPEDIA
Family BALANIDAE

Balanus amphitrite niveus Darwin
Conchie Channel, Sandy Key Basin. Abundant on any solid submerged object. Occasional in Coot Bay near the mouth of the Buttonwood Canal and in the Shark River-Oyster Bay complex during periods of high salinity. OSR 25; 32-38

Balanus eburneus Gould Ivory Barnacle
Found in varying abundance from the shore of Florida Bay, where it fails to compete with *B. amphitrite niveus,* to the northern shore of Whitewater Bay. Studies on spawning indicate some spawning throughout the entire year with a major peak in November and December and a minor peak in June. A maximum growth of 18.5-mm disc diameter in five weeks was observed in June-July, 1959, and some individuals had reached sexual maturity at that time. Intensive studies are now being undertaken on the ecology of this species since

it offers considerable promise as an indicator of the physical environment. OSR 0; 6-30; 40

Chelonibia patula (Ranzani) Turtle Barnacle
Several specimens were found on spider crabs, *Libinia dubia* (Majidae), collected off East Cape Sable. OS 36

Subclass MALACOSTRACA
Order ISOPODA
Family ANTHURIDAE

Cyathura polita (Stimpson)
Several specimens were collected burrowing in intertidal marl spoilbanks off Flamingo in Florida Bay. This species was recently studied by Miller and Burbanck (1961). OSR 0-40

Family CIROLANIDAE

Cirolana parva Hansen
Tarpon Creek at the northwest end of Coot Bay in the plankton. OSR 16-20

Family CYMOTHOIDAE

Cymothoa carabaica Bovallius
Two specimens were found free in a trawl sample from Sandy Key Basin. OS 35

Cymothoa excisa Perty
One specimen taken from the mouth of a striped mullet, *Mugil cephalus,* and one from the tongue of a silver perch, *Bairdiella chrysura,* both from Florida Bay. Common in the oral cavity of the pigfish, *Orthopristis chrysopterus.* OS 35

Family SPHAEROMIDAE

Sphaeroma destructor Richardson Gribble
Very abundant in the Coot Bay area and in western Whitewater Bay complex during the fall and winter of 1957 and 1958. Collected in large quantities in the plankton on the night ebb tides. Preferred habitat in the brackish bays, mangrove oyster clumps and in barnacle clusters where each dead shell houses at least one and sometimes many individuals. Has been collected rarely since the winter of 1958 probably as a result of decreased salinities. OSR 7; 25-39; 41

Cilicaea caudata (Say)
Very common on *Thalassia* flats in Florida Bay. OSR 37-38

Family Idotheidae

Cleantis planicauda Benedict
Buttonwood Canal at Coot Bay in the plankton. Common in the grasses in Coot Bay. OSR 18-32

Family Ligidae

Ligia baudiniana (H. Milne-Edwards)
Very common along the banks of Buttonwood Canal and on the seawall at Flamingo. Not in the Shark River.

Order STOMATOPODA
Family Squillidae

Squilla empusa Say
Oyster Bay, Clearwater Pass and several stations in Florida Bay. Larvae, probably of this species, were taken by trawl in Conchie Channel in Florida Bay. This species was also reported from brackish water in Chesapeake Bay (Cowles, 1930). OSR 16-38

Squilla prasinolineata Dana
Sandy Key Basin, and off East Cape Sable. Six specimens of this rare species were collected. OS 37

Order DECAPODA
Supersection Natantia
Family Penaeidae

Penaeus duorarum Burkenroad Pink Shrimp
The most abundant penaeid in the study area, with juveniles common at all stations throughout the year. Up to 1,900 individuals were taken by dipnet in a two hour period at the Coot Bay end of the Buttonwood Canal. Salinity range 0-40‰ with the smallest specimens collected in the lower part of the range. Largest numbers of small shrimp in the brackish-water area during the months of June through September. In the late fall and winter, the shrimp leave the area when they measure approximately 18 to 25 mm carapace length. The destination of the shrimp after leaving the inshore shallows has been suggested by specimens tagged and marked in the Cape Sable region being recovered in the Dry Tortugas shrimp grounds some 65 miles to the southwest of Flamingo. OSR 0; 6-40; 47
OTR 19-33

Penaeus aztecus Ives
Collected in samples of *P. duorarum*. Never abundant. Five indi-

viduals collected in a sample of 424 penaeid shrimp. There is no information concerning seasonal distribution.

Penaeopsis goodei (Smith)
Gulf of Mexico, off the Shark River, in the plankton.

Sicyonia dorsalis Kingsley
Gulf of Mexico, off the Shark River, in the plankton.

Sicyonia typica (Boeck)
Juveniles were collected in the fall, winter and spring in small numbers in Oyster Bay and Clearwater Pass, and at several stations in Florida Bay. This species apparently prefers high salinity. OSR 22-37

Trachypenaeus constrictus (Stimpson)
30 specimens collected in 12 locations, in Sandy Key Basin, Joe Kemp Channel and Conchie Channel of Florida Bay and in west Whitewater Bay. Juveniles only (to 30 mm total length) were collected. Six collections made during the months of November and December, and six collections made during March and April. OSR 26-37

Family Sergestidae

Lucifer faxoni Borradaile
Gulf of Mexico off the Shark River, and in Buttonwood Canal, in the plankton during periods of high salinity. OSR 30-38

Family Alpheidae

Alpheus armillatus (H. Milne-Edwards)
Several specimens were collected in a sponge off East Cape Sable. See remarks under *A. heterochaelis,* below. OS 34

Alpheus heterochaelis (Say)
Very common in Clearwater Pass and Coot Bay until the winter of 1959. Much less common since then. Also found in Oyster Bay and Florida Bay. Apparently prefers soft mud substratum. There was no apparent overlap between this species and *A. armillatus* as reported by Behre (1950) in Louisiana. Ovigerous females collected in March, 1958, and April and July, 1959. Very abundant on the surface in tidal channels during the ebb tides in the months of September through January. OSR 6-38

Alpheus normanni Kingsley
Common at most stations in Florida Bay, less common in western Whitewater Bay. Chace (1937) pointed out that this was the correct name for *A. packardii* Kingsley. Ovigerous females were collected in

November, 1958, and February and March, 1959. OSR 25-38

Synalpheus apioceros Coutiere
One ovigerous female was taken off East Cape Sable in a sponge in March, 1959. OS 34

Synalpheus brevicarpus (Herrick)
Several specimens were taken in Sandy Key Basin and off East Cape Sable in sponges. Ovigerous females were collected in August and December, 1958. OSR 32-39

Synalpheus herricki Coutiere
Found in sponge in Sandy Key Basin along with the following species. OS 33

Synalpheus pectiniger Coutiere
One ovigerous female was collected in a sponge, in Sandy Key Basin, during January, 1959. OS 33

Family Hippolytidae

Hippolyte pleuracantha (Stimpson)
Very abundant in the *Thalassia* flats of Florida Bay, uncommon in the vegetation of Coot and Whitewater Bays. One five minute trawl drag in Sandy Key Basin in April, 1959, yielded 129 specimens. Ovigerous females collected during February and April, 1959. OSR 25-38

Hippolysmata wurdemanni (Gibbes)
Several specimens were collected in sponges in Florida Bay. One ovigerous female observed in January, 1959. OSR 32-37

Latreutes fucorum (Fabricius)
Common in Florida Bay, less abundant in Whitewater Bay. Ovigerous females were noted in October, 1958, and March and April, 1959. OSR 22; 33-37

Latreutes parvulus (Stimpson)
One ovigerous female was collected in March, 1959. off East Cape Sable. OS 34

Thor floridanus Kingsley
Common in Florida Bay, less abundant in Clearwater Pass of western Whitewater Bay. Apparently prefers normal (35‰) sea salinity. Ovigerous females were noted in August, 1957, August, 1958, and January, March and April, 1959. OSR 22; 27-37

Tozeuma carolinensis Kingsley
Common at all stations in Florida Bay, entering Coot and western Whitewater Bays during periods of high salinity. Ovigerous females

were noted in December, 1957, August, November, and December, 1958, and January, March, April and May, 1959. OSR 27-38

Family Ogyrididae

Ogyrides yaquiensis Armstrong

One specimen was collected in Conchie Channel off Flamingo, in June, 1959. Previously known only from the Dominican Republic (Armstrong, 1949). The present material closely resembles *O. limicola* Williams from brackish water in the Carolinas. OS 39

Family Palaemonidae

Leander paulensis Ortmann

This shrimp is distinct from *L. tenuicornis* (Say) and is tentatively referred to *L. paulensis*. A complete description of the Florida Bay material was made (Manning, 1962). This species was common at all stations in Florida Bay, occasionally found in Whitewater and Coot Bays. Ovigerous females were noted in August, 1957, August and October, 1958, and February, March, and April, 1959. OSR 12-38

Palaemon floridanus Chace

Less numerous than *Leander paulensis*, this species was collected only in Florida Bay. Ovigerous females were noted in August, 1958, and April, 1959. OSR 34-38

Palaemonetes intermedius Holthuis

Very abundant in Clearwater Pass, western Whitewater Bay. less abundant in the remainder of Whitewater and Coot Bays. Extremely abundant in Bear and West Lakes, in winter only. Ovigerous females were noted in December, 1957, January, August, October and November, 1958, and January, February and April, 1959. OSR 6-38

Palaemonetes paludosus Gibbes

Specimens were collected at several fresh-water culvert pools along the road north of Flamingo. Many specimens were collected in brackish water in West Lake in January, 1959. OSR 0-10

Palaemonetes pugio Holthuis

Several specimens were collected along with *P. intermedius* in Bear Lake in January, 1959. It was not found alone or mixed with *P. intermedius* at any of the other low salinity stations in the area. OS 17

Periclimenes americanus (Kingsley)

Common in Oyster Bay and Clearwater Pass areas of western Whitewater Bay. Less common in Coot and Florida Bays. Ovigerous females

were noted in January, October and December, 1958, and February, March and April, 1959. OSR 12-38

Periclimenes longicaudatus Stimpson
Very abundant in Florida Bay, uncommon in Coot and Whitewater Bays except during periods of high salinity. Ovigerous females were noted in February, March and April, 1959. OSR 22; 28-48

Family Processidae

Processa sp.
One specimen collected in Sandy Key Basin. OS 37

Family Pasiphaeidae

Leptochela serratorbita Bate
Gulf of Mexico, 12 miles south of the mouth of the Shark River, in the plankton. Ovigerous females were taken in March, 1959.

Family Astacidae

Procambarus alleni Faxon
Common throughout the marl prairies from Flamingo to Paurotis Pond north of Nine-Mile Bend on the Park Highway. Also abundant in the rocky pinelands of Long Pine Key near the Florida City entrance to the Park. Large quantities of this species are consumed by racoons, crows and wading birds as well as by fresh-water bass and sunfish. Predation is greatest at the onset of the dry season as water levels fall, and during the rainy season when the crayfish move about at night. *P. alleni* builds pellet mounds at the mouth of its burrow in marl soil, but may live in burrows without mounds in rocky soil. They are often found burrowing immediately adjacent to the fiddler crab *Uca rapax* in the Flamingo marl prairie.

Family Palinuridae

Panulirus argus (Latreille)
Three juveniles, all under 50 mm in length, collected in Florida Bay at Joe Kemp Channel. Rare in the muddy bottoms of northern Florida Bay. OSR 32-35

Family Scyllaridae

Scyllarus americanus (Smith)
Two specimens were collected in Conchie Channel. OSR 34-38

Supersection REPTANTIA
Section ANOMURA
Family PORCELLANIDAE

Euceramus praelongus Stimpson
Two specimens of this rare species were collected in Florida Bay, and one (April, 1959) was ovigerous. OSR 34-37

Petrolisthes armatus Gibbes
Extremely common in all areas in sponges, on bryozoans, in oyster clumps, and intertidally under sticks and rocks. Ovigerous females were collected in October, 1958, and April and May, 1959. OSR 12-44

Petrolisthes galathinus (Bosc)
Several specimens were collected in Florida Bay in a sponge also inhabited by *P. armatus*. Wass (1955) reported no overlap in the habitat of these two species at Alligator Harbor, Florida. OS 32

Porcellanopsis soriata Say
Several specimens were collected in Florida Bay off East Cape Sable. They may be found in sponges with *P. armatus*. One ovigerous female noted in March, 1959. OSR 32-34

Family DIOGENIDAE

Paguristes tortugae Schmitt
On hard shell sand bottom in Florida Bay. OSR 32-37

Petrochirus diogenes (Linnaeus)
Formerly known as *P. bahamensis*. One juvenile was collected off East Cape Sable. OS 31

Family PAGURIDAE

Pagurus annulipes (Stimpson)
Extremely abundant on grass flats (*Thalassia*), at all stations in Florida Bay, less common in western Whitewater Bay. Ovigerous females were noted in November, 1958, and February, 1959. OSR 16-38

Pagurus impressus (Benedict)
One specimen taken in Conchie Channel off Flamingo in February, 1959.

Pagurus longicarpus Say
One specimen was collected in Joe Kemp Channel southeast of Flamingo, in October, 1958.

Pagurus pollicaris Say
Several specimens were collected on hard shell sand bottom of Conchie Channel. OSR 30-37

Section BRACHYURA
Family LEUCOSIIDAE

Persephona aquilonaris Rathbun
Several specimens were collected in Florida Bay. Uncommon. OS 38

Ebalia cariosa (Stimpson)
Occasionally collected in Florida Bay, present in western Whitewater Bay only during periods of high salinity. OSR 22; 34-38

Family PORTUNIDAE

Callinectes sapidus Rathbun
Common at all times of the year at all stations, may penetrate fresh water for distances of five or more miles. OSR 0-38

Portunus gibbesii (Stimpson)
Collected in Coot Bay in September, 1957, when salinities were between 28 and 32‰. Found feeding there upon massive concentrations of cyprinodont fishes that had been driven from the mangrove swamps into the bay edges by oxygen depletion. Found at all Florida Bay stations. OSR 28-40

Portunus spinimanus Latreille
Several small specimens of this species were collected in Florida Bay. Many juvenile portunids, not identifiable to species, were collected throughout the study period in salinities ranging from 12 to 38‰.

Family XANTHIDAE

Eurypanopeus depressus (Smith)
Common on oysters in Tarpon Creek, western Coot Bay. Ovigerous females were noted in November, 1958, and January, 1959. Observed salinity range 11-19‰, with a salinity range from 10-26‰ at that station for the two year period. OSR 11-19

Eurytium limosum (Say)
Cormorant Pass, between Clearwater Pass and Oyster Bay, and off Flamingo in Florida Bay. In marl and organic muds above the low tide line. Only juveniles were collected.

Menippe mercenaria (Say) Stone Crab
Found as juveniles at all Florida Bay stations, also in the Shark River and western Whitewater Bay. Adults frequent the deeper waters off-

shore from East Cape Sable to Fort Myers and beyond on the southwest coast. In 1959, there were approximately 900 traps for this species, between East Cape Sable and the Harney River. OSR 17-37

Neopanope packardii (Kingsley)
Common at all Florida Bay stations, occasional in western Whitewater Bay. Ovigerous females noted in October and December, 1958, and March, 1959. OSR 22; 28-38

Neopanope texana texana (Stimpson)
Common in Florida Bay and western Whitewater Bay. Ovigerous females were noted in October and November, 1958. Apparently is more tolerant of low sailinities than *N. packardii*. OSR 12-38

Panopeus americanus Saussure
Off Flamingo in Florida Bay and occasional in western Whitewater Bay. OSR 12-25

Panopeus occidentalis Saussure
Off East Cape Sable in Florida Bay and along the shores of Buttonwood Canal. Common, usually intertidal.

Pilumnus lacteus Stimpson
Common at all stations in beds of *Thalassia* of Florida Bay. Ovigerous females were noted in July, August and October, 1958, and February, March and April, 1959. OSR 31-38

Rhithropanopeus harrisii (Gould)
Very common in eastern Whitewater and Coot Bays, in areas of low salinity. Ovigerous females were collected in June and July, 1958. OSR 6-21

Family Goneplacidae

Eucratopsis crassimanus (Dana)
Occasional in Oyster Bay. Ovigerous females collected in October, 1958. OS 25

Family Pinnotheridae

Pinnixa sp.
Off East Cape Sable in Florida Bay. Two specimens of this unidentified species were taken in September, 1958.

Pinnotheres maculatus Say
Sandy Key Basin in Florida Bay. Several specimens were found in the mantle cavities of the bay scallop, *Aequipecten irridians*, in October, 1958.

Family Grapsidae

Aratus pisonii (Milne-Edwards)
Common on the Flamingo marina seawall and on mangroves in all shoreline areas.

Sesarma curacaoense De Man
Cormorant Pass, western Whitewater Bay, on mangroves. This is the first American record for this species.

Sesarma reticulatum (Say)
Cormorant Pass, western Whitewater Bay, on mangroves. One of the species that occurs frequently in the stomachs of gray snapper, *Lutjanus griseus*. This is the first south Florida record for this species, previously thought to be a typical Gulf of Mexico disjunct.

Family Ocypodidae

Uca pugilator (Bosc)
Flamingo Beach, Buttonwood Canal and Cormorant Pass in western Whitewater Bay. Prefers soft, wet mud to the drier marl.

Uca rapax (Smith)
Buttonwood Canal at Flamingo, Flamingo Beach, marl flat along Buttonwood Canal north of Park highway bridge and shores of Coot Bay Pond. Prefers hard marl for burrowing. The recent work of Tashian and Vernberg (1958) has shown that this species is distinct from *U. pugnax*. It had previously been considered but a subspecies of the latter.

Uca speciosa (Ives)
Flamingo Beach, Buttonwood Canal south of Park highway bridge, mud flats off Flamingo and Cormorant Pass in western Whitewater Bay. Constructs its burrows in the soft muds, richly charged with plant fibers, at the top of the intertidal zone. Feeds on exposed shorelines during low tides.

Uca thayeri Rathbun
Buttonwood Canal, north of Park highway bridge, in the black mangrove belt of rich, peaty soils.

All the above species of fiddler crabs contribute to a certain extent, by their burrowing action, to the erosion and breakdown of the marl shorelines of the Buttonwood Canal and Flamingo Beach area. *U. rapax* is a strong digger, constructing burrows in the firm marl to depths of 40 or more centimeters.

Family Majidae

Libinia dubia Milne-Edwards
Common at all Florida Bay stations, occasional in western Whitewater Bay. Small individuals most often found in *Thalassia,* while adults occur in about equal numbers in *Thalassia* and the sponge-algae associes of the deeper channels in Florida Bay. OSR 25-38

Libinia erinacea (Milne-Edwards)
Specimens corresponding to the descriptions given by Rathbun (1925) were collected at all stations in Florida Bay. Larger specimens of this species showed strong suggestions of intergradation with those identified as *L. dubia.* The fact that no ovigerous females of *L. erinacea* were found adds further evident for re-evaluating the validity of the two species from a taxonomic standpoint. Raymond B. Manning is conducting such a study. OSR 22; 29-38

Metoporhaphis calcarata (Say)
Common in Florida Bay, occasional in western Whitewater Bay during periods of high salinity. One specimen was observed drifting at the surface in Sandy Key Basin. Wass (1955) also observed this phenomenon. OSR 22; 28-35

Pelia mutica (Gibbes)
Common in Florida Bay, occasional in western Whitewater Bay to Clearwater Pass, during periods of high salinity. Ovigerous females were collected in October, 1958, and February, 1959. All specimens were completely masked with sponges, hydroids or algae.
OSR 22; 32-38

Pitho anisodon (von Martens)
Found in western Whitewater Bay (Clearwater Pass and Oyster Bay) during the summer and fall of 1957 when salinities ranged between 32 and 35‰. Occasional in Sandy Key Basin, Florida Bay. One ovigerous female was collected in March, 1959. OSR 22; 32-35

Podochela riisei (Stimpson)
Occasional in Florida Bay. OSR 31-38

Family Parthenopidae

Heterocrypta granulata (Gibbes)
Two specimens were collected on hard shell-sand bottom off East Cape Sable. OS 36

PYCNOGONIDA
Family PHOXICHILIDIIDAE

Anaplodactylus insignis (Hoek)
Uncommon in Florida Bay, part of the *Thalassia* biotope. OSR 31-39
Anaplodactylus lentus Wilson
A small series of these pycnogonids was collected in the plankton at the Coot Bay end of Buttonwood Canal in July, 1959. Probably common, but their small size and peculiar structure make them easily overlooked.

FISHES

Identifications of most fishes were made by the senior author. In some difficult groups such as the pipefishes and herring-like fishes, identifications were made by Dr. C. Richard Robins, Curator of Fishes, The Marine Laboratory. The common and scientific names are those given by Bailey, *et al.* (1960). References used in identifying material are those by Bigelow and Schroeder (1948, 1953), Breder (1948), Briggs (1958), Ginsburg (1931, 1932, 1933, 1937, 1950, 1951, 1952, 1952a, 1953, 1954), Hildebrand (1943), Jordan and Evermann (1898), Schultz (1958), Springer (1954, 1959) and Welsh and Breder (1923). In addition, the specimens have been compared with specimens in the fish collections of The Marine Laboratory. The rare or unusual fishes as well as series collections of all material have been deposited in The Marine Laboratory fish collection. In cases where they have been cataloged, and these are mentioned in this paper, the catalog number prefixed by the letters UMML will refer the reader to the material.

Class *CHONDRICHTHYES*
Order SQUALIFORMES (Selachii)
Family ORECTOLOBIDAE (Nurse Sharks)

Ginglymostoma cirratum (Bonnaterre). Nurse Shark
Florida Bay at all stations. Never abundant in the muddy waters along the mainland shore. Not observed in Coot or Whitewater Bays.
OSR 28-37

Family CARCHARHINIDAE (Requiem Sharks)

Carcharhinus limbatus (Müller and Henle) Blacktip Shark
The most abundant shark of the shallow water of Florida Bay and associated brackish-water areas. It invades areas of low salinity on the flood tides and exits on the ebb tides. Though generally small, this

species is exceedingly active and aggressive. It accounts for most fish-catch losses in Everglades National Park and will strike at surface disturbances in muddy water. Two- to three-pound pups abundant on *Thalassia* flats in July, August and September. Uncommon during the months of December through February. OSR 15-35 OTR 22-33

Negaprion brevirostris (Poey) Lemon Shark
Recorded by Henshall (1891) from Cape Sable Creek. Not observed during the present study.

Scoliodon terraenovae (Richardson) Atlantic Sharpnose Shark
Henshall *(op. cit.)* reported this shark as common in the Cape Sable Creek area. Not observed during this investigation.

Order RAJIFORMES

Family Pristidae (Sawfishes)

Pristis pectinatus Latham Smalltooth Sawfish
Common though not often seen in Florida Bay and the brackish waters of the Florida mainland. Large specimens 8 to 15 feet long occasionally landed by anglers. On March 16, 1961, Mr. William Boyd, Jr. of Louisville, Kentucky, hooked and landed a sawfish in Snake Bight, east of Joe Kemp Key. This fish was 15.5 feet in length and weighed 501 pounds.This fish was just six inches shorter than the world record for this species taken at Ft. Amador, Panama Canal Zone. Apparently solitary in habit. One individual was observed in the shallow water of Coot Bay Pond during three consecutive months (August, September and October) of 1957, suggesting that they may exhibit some territoriality. OSR 6-32

Family Dasyatidae (Sting Rays)

Dasyatis americana Hildebrand and Schroeder Southern Stingray
Not abundant in the study area. Large specimens most often observed in Florida Bay while small individuals occur in Coot and Whitewater Bays. Mudlines made by feeding rays are favored feeding areas for fish such as red drum, spotted seatrout and snappers. OSR 15-37

Family Aetobatidae (Eagle Rays)

Rhinoptera bonasus (Mitchill) Cownose Bay
The cownose ray was reported by Henshall (1891) from Cape Sable. It has been observed by the authors in Sandy Key Basin, Joe Kemp Channel and in the main channel of the Shark River at Ponce de

Leon Bay. A fish of deeper, open waters. Not common in the muddy shallows of northern Florida Bay. OSR 32-37

Class *OSTEICHTHYES* (Bony fishes)
Order SEMIONOTIFORMES
Family LEPISOSTEIDAE (Gars)

Lepisosteus platyrhincus De Kay Florida Gar
One of the dominant, large fishes of the Everglades fresh-water habitat that may invade brackish areas during periods of heavy rainfall. Observed regularly at Coot Bay Pond during the rainy period July through September. They undergo radical color change in brackish water, from the normal green with black barkings to a rich bronze with lavender markings. OSR 0-18

Order CLUPEIFORMES (Isospondyli)
Family ELOPIDAE (Tarpons)

Elops saurus Linnaeus Ladyfish
All stations from fresh to full strength sea water. Large adults most often caught in the Shark River estuary and in the deeper water of Florida Bay. Juveniles most abundant in the shallow, mangrove bordered ponds, lakes and bays of the mainland. Juveniles 10 to 18 cm fork length were killed by oxygen depletion following hurricane DONNA, in the Nine-mile Bend area, along with freshwater bass, sunfish and yellow bullheads. Larvae abundant in the plankton from September through December. OSR 0; 5-34

Megalops atlantica Valenciennes Tarpon
All stations. A year around resident with an apparent peak in abundance during the period August through January. Juveniles 40 to 150 mm abundant in Coot Bay Pond and similar shallow bays from June through October. In August and September each year, juveniles and sub-adults congregate in very large numbers at certain locations, particularly in Bear and Mud Lakes and feed on vast quantities of several species of cyprinodont fishes and prawns, *Palaemonetes intermedius*. This feeding "jubilee" corresponds with the end of the rainy season and an attendant oxygen depletion which forces the small fish and prawns from the flooded swamps into the open margins of bays. The cold wave of December 11, 12 and 13, 1957, killed many tarpon as well as other species. Dead specimens ranging between 10 and 40 cm were found throughout Coot Bay and Whitewater Bay. Bottom

water temperatures of 12 to 14°C were prevalent in all the shallow brackish areas at the time of the kill. OSR 0-37

Family Clupeidae (Herrings)

Brevoortia smithi Hildebrand Yellowfin Shad
Uncommon in inshore waters. Collected on five different occasions. Adults taken in February, 1959, and March, 1960, in Conchie Channel. Juveniles in large numbers were collected during August and September, 1957, at Coot Bay Pond and Tarpon Creek. When present, these fishes are easily observed and collected. Their absence from collections suggests a general scarcity in the area except in the fall and winter. OSR 12-38

Harengula pensacolae Goode and Bean Scaled Sardine
Abundant in the Coot Bay-Whitewater Bay complex during the fall of 1957 when salinities were at the highest point during the observation period. They have not been collected or observed since that time. OSR 14-30

Opisthonema oglinum (LeSueur) Atlantic Thread Herring
Another example of a formerly abundant species that has apparently been driven from inshore waters by the prevailing low salinities during the period January, 1958, through January, 1961. Large series of juveniles were collected during April and October, 1957, and during July and August, 1958. OSR 15-33

Family Engraulidae (Anchovies)

Anchoa cubana (Poey) Cuban Anchovy
Collected in Joe Kemp and Conchie Channels in Florida Bay in April, 1958 and 1959. OSR 32-36

Anchoa hepsetus (Linnaeus) Striped Anchovy
Numerically most abundant species in Florida Bay collections. Recorded in samples for the months of October through May, 1957-58 and 1958-59. OSR 28-48

Anchoa mitchilli (Valenciennes) Bay Anchovy
Most abundant fish of brackish water in Everglades National Park. Collected during all months of the year in Coot and Whitewater Bays. Larvae and juveniles occur in great abundance in the Coot and Whitewater Bay area during the period September through November. Adults least abundant in brackish areas during December through February. OSR 0-30

Order MYCTOPHIFORMES (Iniomi)
Family SYNODONTIDAE (Lizardfish)

Synodus foetens (Linnaeus) Inshore Lizardfish

One species that declined in abundance since the winter of 1957. Lizardfish mortality was apparently complete in Whitewater and Coot Bays following the severe chilling of December 11 through 13, 1957. Prior to that time this lizardfish was common on the vegetated marl bottoms of Whitewater and Coot Bays. Only a few individuals have been collected since the freeze kill. Temperatures on the bottom during the freeze ranged between 12 and 14°C. Reid (1954) reported that he collected this species alive when water temperatures were as low as 8.3°C. OSR 8-36
OTR 12; 17-32

Order CYPRINIFORMES (Ostariophysi)
Family ARIIDAE (Sea Catfishes)

Bagre marinus (Mitchill) Gafftopsail Catfish

Rare in trawl samples, but common in the catches of sportsmen and commercial fishermen. Rosen and Dobkin (1959) and Higman and Stewart (1961) show that "catfish" meaning this and the following species make up the third largest segment of angler catches in Everglades Park waters. Rosen and Dobkin state that catfish made up an average of 20.3 per cent of the total catch in point of numbers during the period March through September, 1958. Higman and Stewart list catfish as comprising 20.0 per cent of the total catch during the period July, 1959 through June, 1960. Catches of catfish as per cent of the total monthly catch are shown (Table 1). The problem of proportional numbers posed by this combination of two species of marine catfishes we feel is resolved by a set of fortuitous observations on fish kills due to total oxygen depletion in Coot and Whitewater Bays following hurricane DONNA in September, 1960. Following the

TABLE 1

SEA CATFISH (*Galeichthys felis*) AS PER CENT OF THE TOTAL MONTHLY ANGLER CATCH FROM EVERGLADES NATIONAL PARK.

Angler category	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Mean
1. Week day	28.1	17.4	17.7	11.4	7.0	20.4	5.4	12.3	12.2	19.5	26.9	39.9	18.2
2. Week end	39.9	18.6	14.9	23.2	23.1	19.9	14.7	21.1	17.5	29.4	20.9	18.7	21.8

oxygen depletion great quantities of fish were washed into eddies and pockets along the shore line of Coot and Florida Bays. Counts of these fishes were made and the gafftopsail catfish made up approximately 10 per cent of the total catfishes counted.

One can see in Table 1 that the catfish are most abundant in catches during the period April through September and are taken in least abundance in the period December through February. OSR 18-37

Galeichthys felis (Linnaeus) Sea Catfish

The sea catfish as the above discussion states is the more abundant of the two species in the survey area. It is commonly taken by anglers, and is considered a nuisance. It occurs throughout the study area from nearly fresh to above normal sea salinities. Apparently it is most abundant in the channels of Florida Bay and in the deeper portions of western Whitewater Bay. OSR 4-37

Family ICTALURIDAE (Freshwater Catfishes)

Ictalurus natalis (LeSueur) Yellow Bullhead

The yellow bullhead is a common member of the Everglades freshwater fauna that is found well into the mangrove zone during periods of heavy rainfall. Of interest in this study since it occurs in the same water with small tarpon, snook, ladyfish, striped mojarra and largemouth gobies. It is a true freshwater fish however and interestingly enough has not been taken on the down stream side of the new Everglades Park highway in the region north of Coot Bay Pond. Collected in roadside pools as far south as West Lake. OSR 0-2

Noturus gyrinus (Mitchill) Tadpole Madtom

Series of tadpole madtoms were collected at several roadside stations between Coot Bay Pond and Nine-mile Bend in March, 1959, during a period of extreme dryness. OSR 0-4

Order ANGUILLIFORMES (Apodes)

Family ANGUILLIDAE (Freshwater Eels)

Anguilla rostrata (LeSueur) American Eel

Six specimens of the American eel were collected while dipnetting at night. These specimens ranging from 10 to 30 cm in length were all captured on the ebbing tide during the months of November through March. These as well as the snake eels exhibit surface movements at night in the winter months and the majority are moving off-shore at this time. Several large individuals approximately 100 cm in length were observed dead following hurricane DONNA in September, 1960. OSR 19-34

Family MURAENIDAE (Morays)

Gymnothorax moringa (Cuvier) Spotted Moray
The spotted moray was collected once, in October, 1959, in Sandy Key Basin. Rare in the survey area probably because of the scarcity of suitable rocky habitat. OS 35

Gymnothorax nigromarginatus (Girard) Blackedge Moray
Three specimens collected in October, 1959, in Sandy Key Basin. OS 35

Family OPHICHTHIDAE (Snake Eels)

Ahlia egmontis (Jordan) Key Worm Eel
The Key worm eel is one of the species that can rightfully be called abundant in the study area although it would probably be absent from most collections made with seines, trawls or bottom grab. It is nocturnal in habit and often moves freely on the surface at night. It is collected most abundantly during the period August through February with a peak of numbers in the catch somewhere between December and February. All but one of the several hundred collected were taken under night lights with dip nets on the surface of canals and natural channels leading from the Coot and Whitewater Bay area. Greatest activity, and that with seemingly definite purpose is their movement seaward on the ebb tides in late fall and early winter. They are accompanied by a distinct group of other fishes and invertebrates on winter ebb tide movements. The peak of numbers in catches is greatest during the onset of the first severe cold weather of winter OSR 22-35

Bascanichthys teres (Goode and Bean) Sooty Eel
The sooty eel is the common large eel of the deeper muddy bottomed channels of Florida Bay. Four specimens were taken by wire trap in Conchie Channel during the period January through April, 1959. Eels of this genus are poorly known and this identification is provisional. The small number collected by us is not a true picture of abundance. They are found in nearly all stone crab pot sets off Cape Sable. OSR 28-35

Myrophis punctatus Lütken Speckled Worm Eel
Common small eel of soft mud bottoms throughout the study area. Seldom collected except at night when it swims actively at the surface. One of the common participants in seaward movements on night ebb tides of late fall and winter at which time it can be collected in large numbers. Observed most abundantly during the period August

through December each year. Very abundant in Coot Bay during the winter of 1957-58, less so during the winter of 1959-60, and has been observed only as single specimens since then. OSR 17-37
OTR 16-33

Ophichthus gomesi (Castelnau) Shrimp Eel
The common large eel of rocky or coarse shell bottoms of Florida Bay off Flamingo. Single specimens of small size (less than 20 mm) occasionally collected at the outlets of Coot and Whitewater Bays along with samples of *Myrophis punctatus* and *Ahlia egmontis*. Readily trapped in wire cone traps baited with cut fish. OSR 16-48
OTR 25-27

ORDER BELONIFORMES

Family BELONIDAE (Needlefishes)

Strongylura notata (Poey) Redfin Needlefish
Common in Florida Bay and in the tidal channels and higher salinity portions of Coot Bay and the Shark River. Most active in early morning and late evening when it feeds heavily on small shrimp, larval and post-larval anchovies, and ladyfish as well as other small swimming prey. OSR 15-35
OTR 26-30

Strongylura timucu (Walbaum) Timucu
The common needlefish of brackish water in the study area, also occuring in higher salinities of Florida Bay. OSR 9-37
OTR 15-30

Family HEMIRAMPHIDAE (Halfbeaks)

Chriodorus atherinoides Goode and Bean Hardhead Halfbeak
Least common of the halfbeaks in Florida Bay samples. Collected twice in Joe Kemp Channel and once in Sandy Key Basin by night light. Never collected in brackish areas. Hardheads are abundant in the Florida Keys and are primarily inhabitants of clear water. The high turbidity areas of northern Florida Bay off Flamingo are not heavily populated by this species. Collected during the period September through December, 1959. OSR 30-35
OTR 22-27

Hemiramphus brasiliensis (Linnaeus) Ballyhoo
Full adults to 25 cm in length observed once in deep water three to ten miles west and south of Middle Cape Sable in September, 1958. At that time, the fish were massed in dense schools at the surface.

These schools were approximately 20 to 50 yards across. Small blacktip sharks were actively feeding on ballyhoo at the outer fringes of the schools and strangely enough with little escape reaction on the part of the ballyhoo. Young specimens are commonly seen and collected in the Shark River estuary in the early winter and as far as Joe Kemp Channel in the eastern portion of the survey area. *H. brasiliensis* suffered extensive mortality due to turbulence and high turbidities produced by hurricane DONNA in September, 1960. OSR 28-36
OTR 20-32

Hyporhamphus hildebrandi Jordan and Everman Halfbeak
Collected twice in small series during November, 1957, and February, 1959. Appears to prefer the shallow, murky water immediately adjacent to the mainland while the following species occurs most abundantly as adults off Cape Sable and the deeper waters of Florida Bay.
OSR 33-37
OTR 19-23

Hyporhamphus unifasciatus (Ranzani) Halfbeak
The common halfbeak of the brackish water of Coot and Whitewater Bays. Never abundant nor has it been observed in schools but it can be collected through the summer and early winter while dip-netting under lights. This is one of the species that participates in the annual exodus from the inner bays at the onset of cold weather in November and December. OSR 20-37
OTR 23-29

Order CYPRINODONTIFORMES (Microcyprini)
Family CYPRINODONTIDAE (Killifishes)

Adinia xenica (Jordan and Gilbert) Diamond Killifish
Five hundred and sixty-two adults and advanced juveniles taken with a very large number of other cyprinodonts in a single sweep of a small collecting dip net at the junction of the old Homestead and the new Buttonwood canals on September 13, 1957. This unusual occurrence was the result of an annual oxygen depletion which follows the rainy season each fall as water temperatures reach peak levels. The large sample was taken from a massed concentration of many thousands of individuals that had been driven from the surrounding swamp pools into the old canal and thence because of still poorer oxygen conditions were forced into the edge of the tidal Buttonwood Canal. In this exposed location they were easy prey for hundreds of wading birds and

blue crabs. Although the concentration of cyprinodont species was unusual because of the tremendous numbers of fishes involved, similar congregations may be found in all the large and small natural outlets from the swamps where they drain into the bays. Low oxygen conditions at this time affect not only the small fish, but also drive masses of shrimp, and larger fish from such areas as Bear, Mud, Fox and West Lakes.

Apparently the diamond killifish have declined in numbers in the area since the high concentration discussed above. They have been taken singly or at the most in small series only three times since in spite of energetic efforts to locate these and other species that have also become less abundant. Probably, the extreme cold of December, 1957, and February, 1958 were responsible for the reduction in numbers since normal oxygen depletions seldom become severe enough to kill all individuals of a species. OSR 0-9; 32
OTR 18-34

Cyprinodon variegatus Lacépède Sheepshead Minnow
Several series were taken at regular swamp pool collecting stations, at Coot Bay Pond and Buttonwood III during 1957. Only 11 were collected since that year even though their favored habitat was sampled repeatedly with nets and rotenone. Prior to their disappearance they were very common in roadside pools and ditches at Coot Bay and in the swamps north of Flamingo. Males were observed in their nuptial colors, brilliant blue capes, during the period April through June. Only a few individuals observed along the Florida Bay shoreline at the mouths of swamp drainage channels or near canals.
OSR 0-26; 35
OTR 13-34

Floridichthys carpio (Günther) Goldspotted Killifish
A rare species in this area, observed only in Florida Bay near shore and along the margins of intertidal mud banks. OSR 27-37
OTR 22-30

Fundulus chrysotus (Günther) Golden Topminnow
Taken at roadside collecting stations 2, 6, 7, 8 and 9 in March, 1959. Subsequent sampling has failed to secure this species. It is found in clear, fresh to slightly salty water. Normally it lives in water having heavy growths of aquatic plants in sunny, open areas. OSR 0-3
OTR 29-33

Fundulus confluentus Goode and Bean Marsh Killifish
Abundant in all marsh pools from Flamingo marl prairies to the sawgrass environment of the freshwater Everglades. Probably third only to the mosquitofish, *Gambusia affinis,* and molly, *Mollienesia latipinna,* in abundance in the mangrove habitat of Everglades National Park. Abundance not affected by the extreme cold of the winter of 1957-58. Difficult to collect with nets since it dives into the debris on the bottom of the swamp pools when disturbed. Not observed in Florida Bay but is often abundant in the shallow margins of Coot Bay Pond and Coot Bay during periods of heavy rainfall. OSR 0-6
OTR 12-34

Fundulus grandis (Baird and Girard) Gulf Killifish
Collected twice, during September, 1957, and November, 1959, in fresh-water stations 9 and 10 in the vicinity of Nine-Mile Bend. Not observed in Florida Bay or in the brackish environment.

Fundulus seminolis Girard Seminole Killifish
Three adults collected in fresh-water collecting station 9 near Nine-Mile Bend in March, 1959. UMML 5113.

Fundulus similis (Baird and Girard) Longnose Killifish
Collected in small numbers at Buttonwood III on September 13, 1957, in company with several thousand individuals of other killifish species during an oxygen depletion. Not common in the study area.

Jordanella floridae Goode and Bean Flagfish
One of those species whose numbers apparently fluctuate widely from year to year in the brackish environment of the study area. Large series were collected at Coot Bay Pond in February and April, 1959 (UMML 4984 and 5946 respectively). Only a few specimens have been collected as single individuals in large samples of other species since the above dates. OSR 0-9
OTR 21-30

Lucania goodei Jordan Bluefin Killifish
Collected in poison stations 2, 4 and 8 in March, 1959. This is a common, though never abundant species in the fresh to brackish pools of the mangrove habitat north of West Lake. It moves back and forth across the area as salinity values fluctuate. Usually found in clear water associated with submerged aquatic vegetation. Never found in the brackish bays as is the following species. OSR 0-3
OTR 22-28

Lucania parva (Baird and Girard) Rainwater Killifish
Collected in September, 1957, in roadside ditch at Coot Bay Pond and in April, 1959, at poison station 4 near West Lake. Observed many times in Coot Bay and Buttonwood Canal and in Florida Bay as far off-shore as Murray Key and Sandy Key. Most abundant in low salinities. OSR 9-28; 35

Rivulus marmoratus Poey Rivulus
This interesting little fish was collected twice during April and May, 1959, in shallow, stagnant pools in the mangrove swamps near Coot Bay Pond. It was taken with small (7 to 25 cm) tarpon and a small sample of mollies. It is exceedingly difficult to collect this species with nets for it burrows deep into the mangrove debris at the bottom of the pools. When using rotenone, the rivulus is the last fish to succumb to the effects of the poison. One must wait until long after the tarpon have surfaced before the rivulus begin to show up along the pool margins. Has extreme tolerance to hydrogen sulphide and other marsh gases and can live in water foul enough to exclude or kill all but tarpon. Probably, this species is much more common than formerly suspected. (UMML 5640, 5905) OSR 0-18
OTR 20-23

Family Poeciliidae (Livebearers)

Gambusia affinis (Baird and Girard) Mosquitofish
By far the most abundant species in the brackish to fresh-water environment in Everglades National Park. Successfully occupies all shallow waters from the sawgrass of the Everglades to the edges of Coot and Whitewater Bays and is found along the shore of Florida Bay during periods of peak run-off from the mainland swamps. It is most abundant in the mangrove belt between West Lake and Flamingo. During dry seasons when surface water falls and is concentrated in pot-holes, this and the following species are concentrated into dense aggregations that are heavily preyed upon by all the many species of herons, ibis and shore birds that live in the Park. Such feeding on the part of the birds quickly decimates the stranded fishes but the following year most appear again in their former abundance. Series collections have been taken at all months of the year. OSR 0-30
OTR 13-37

Heterandria formosa Agassiz Least Killifish
Collected on December 2, 1958, at poison station number 2, Coot

Bay Pond. There had been little rainfall for two months prior to that date, and many species of killifishes were being driven by the falling water table to roadside culvert pools. A series of adults were collected at that time and have not been taken since. This is probably a fairly common species of the clear water in the mangrove belt in the Park, and we have observed it in the fresh-water zone in the vicinity of Nine-mile Bend. It seeks refuge in aquatic vegetation when alarmed rather than diving into the bottom as do some of the other killifishes.

OSR 0-4
OTR 18-22

Mollienesia latipinna LeSueur Sailfin Molly

The second species in point of numbers in the fresh and brackish-waters throughout the study area. Males in nuptial colors from November through February. Equally at home in the hard waters of rock-pits on the mainland and in the coffee-colored, sulphide-rich pools of the deep mangrove swamp. During the late summer, usually in September, mollies are driven from the swamp pools, along with mosquitofish and other killifishes, by oxygen depletion. At this time they enter the margins of brackish bays and even move some distance offshore in Florida Bay. They are heavily preyed upon at that time by wading birds and larger fishes including jewfish, common jack, snook, ladyfish and tarpon. Very large numbers are also eaten by birds, racoons and crabs each winter during the dry season when swamps dry to small pools and concentrate these fishes. OSR 0-33
OTR 13-37

Order GASTEROSTEIFORMES
(Thoracostei-Hemibranchi-Lophobranchii-Solenichthyes)

Family SYNGNATHIDAE (Pipefish and Seahorses)

Hippocampus erectus Perry Spotted Seahorse

All stations in Florida Bay where vegetation is abundant. Taken at all months of the year with an apparent low point in abundance during the months June through September. Usually collected in deeper water than the following species and is more apt to be associated with the marine grass, *Thalassia testudinum,* than with various un-attached algae species as is the following dwarf species. Spotted seahorses were taken in 17 regular monthly collections and many non-regular collections. They were taken inshore as far as Whitewater II on December 17, 1957, and Whitewater VIII on April 22, 1958. They invade Whitewater and Coot Bays during periods of high salinity. OSR 16-35
OTR 17-29

Hippocampus zosterae Jordan and Gilbert Dwarf Seahorse
Abundant in the clearer waters of Florida Bay and in Whitewater Bay during periods of higher salinities. Usually associated with the alga *Gracilaria* or other similar species. Apparently prefers slightly higher salinities than the preceeding species. Taken in greatest numbers during the period November through February. OSR 19-37
OTR 19-26

Syngnathus dunckeri Metzelaar Pugnose Pipefish
This small, shortnosed pipefish was collected in nearly all tows with the trawl in Coot Bay during the latter half of 1957 and until April, 1958. Since that time it has been very rare in that area. Common in Florida Bay in the grassy shallows of Snake Bight and Joe Kemp Channel. Collected in Clearwater Pass on April 22, 1958, when salinities were about 27‰. Most abundant in beds of *Diplanthera,* the narrow marine grass. OSR 20-34
OTR 22-32

Syngnathus floridae (Jordan and Gilbert)
The most abundant pipefish of the study area. Taken most abundantly in the period October through February. Collected once in Clearwater Pass in November, 1958, and in Coot Bay at Tarpon Creek in May, 1958, when salinity values were 17.6 and 21.2‰ respectively.
OSR 17-38
OTR 16-28

Syngnathus scovelli (Evermann and Kendall) Gulf Pipefish
Collections of this pipefish were made at Whitewater and Coot Bay stations, in salinities that were generally lower than those prevailing at time of collecting of the previous species, *S. floridae*. Taken at Whitewater Stations I, VII and VIII, and in Coot Bay during the period November through April, 1958-59. Reported by Springer and Woodburn (1960) as the common pipefish of the Tampa Bay area. This is not true of the present area at least for the period covered by this study which has been one of unusually low inshore salinities most of the time. OSR 6-28
OTR 16-29

Order PERCIFORMES (Percomorphi; Acanthopterygii)
Family CENTROPOMIDAE (Snooks)

Centropomus undecimalis (Bloch) Snook
One of the common, large species of the study area. Large specimens

not collected by the usual collecting apparatus but can be examined in angler catches nearly any day of the year at Flamingo. The biology of this species has been reported by Marshall (1958) and Volpe (1959). Known to be euryhaline and traveling from the sea salinities of outer passes to the fresh-water canals of southern Florida. The young are most often found in the shallow swamp pools frequented by killifish, small tarpon and young stages of the ladyfish. Thirteen small snook were collected on May 12, 1959, in a culvert pool at Coot Bay Pond. The salinity was 33.7‰ and the temperature 28.7°C. Snook mortality observed in December, 1957, when water temperatures in the Coot Bay area and adjacent swamps fell to 11°C. A similar cold period in February, 1958, apparently did not kill any of the survivors of the first cold wave. OSR 0-35
OTR ca 12-33

Family SERRANIDAE (Sea Basses)

Diplectrum formosum (Linnaeus) Sand Perch
Uncommon in the study area. Collected twice, one specimen on January 1, 1958, and two on October 29, 1958, in Conchie Channel and Sandy Key Basin respectively. Probably more abundant on the sand bottoms off Cape Sable in the sponge grounds. UMML 5544.
OSR 31-39
OTR 18-34

Epinephelus itajara (Lichenstein) Jewfish
Common in the deeper channels of the study area. Adults to more than 400 pounds taken in the Shark River estuary and in holes off-shore in Florida Bay. Juveniles from two to fifty pounds taken throughout Coot and Whitewater Bays when salinity values rise above 25‰. This species occasionally observed rooting among mangrove roots at the waters edge, with its tail above water. In the bays, the basic color pattern is yellow-brown with pronounced spotting of sooty black.
OSR 25-37

Epinephelus morio (Valenciennes) Red Grouper
Uncommon in the study area. Those landed at Flamingo by anglers are normally taken in deeper water from one to five miles off Cape Sable.

Epinephelus striatus (Bloch) Nassau Grouper
Uncommon in the study area. Occasional in angler catches from the Shark River estuary and deeper water off Cape Sable.

Mycteroperca microlepis (Good and Bean) Gag
The common grouper of angler catches in the study area. An inhabitant of the clearer, deeper water off East Cape Sable and thence westward. Collected once by the writers in a trawl drag on June 30, 1960, in Sandy Key Basin. UMML 6933. OS 35
OT 29

Family Lobotidae (Tripletails)

Lobotes surinamensis (Bloch) Tripletail
Observed occasionally in the study area. In most instances, observations were of juveniles under 20 cm in length. One individual seen floating flat on the surface in Conchie Channel north of Sandy Key in January, 1959, and three were observed, again floating like leaves on the surface two miles south of Middle Cape Sable on September 10, 1958. Becomes most common in angler catches of late fall and in winter. OS 32-37
OTR 22-30

Family Lutjanidae (Snappers)

Lutjanus griseus (Linnaeus) Gray Snapper
The most common snapper of the study area. Collected in all areas from the fresh water of rivers tributary to Whitewater Bay and the Shark River estuary, to the highest salinities of Florida Bay. One of the most popular species among anglers throughout Everglades National Park. Croker (1960) failed to find any evidence that adult gray snappers existed in the study area. Apparently, the fishery subsists entirely on the juvenile stages. During cold periods in winter gray snappers congregate in the deep channels of fresh-water rivers just north of Whitewater Bay. While there, they become quite dark in color and apparently cease feeding to a great extent. Food items consist largely of shrimp, crabs and various small fish usually in that order. Although the gray snapper occurs in the middle reaches of fresh-water rivers during winter, it probably should not be listed as euryhaline. At all other times, it is found in water containing varying degrees of salt. Gray snappers exhibit marked color change depending upon the nature and color of the water in which they live. In the high marl turbidities of Florida Bay off Flamingo, they are basically gray-green with brick red scale centers and head markings, the over-all impression being that of a gray fish. In the brackish waters of Coot and Whitewater Bays where humic acids often color the water deep coffee

brown, the fish become rich red-bronze to umber. The smallest specimens recorded during this survey were 20 to 35 mm individuals collected at Whitewater Bay VII and Joe Kemp T1, 2, 3, and 4 during the period September through February, 1958. OSR 0-37
OTR 16-31

Lutjanus synagris (Linnaeus) Lane Snapper
Common snapper throughout the brackish and marine waters of the study area. Occurs more often in trawl catches than do gray snapper in Florida Bay. Smallest individuals occur in large numbers in the clear water of the Shark River-Oyster Bay complex and in Joe Kemp Channel during the period September through December. These range in length from 20 to 130 mm. The largest specimen recorded was 22 cm. There is no indication that Lane snapper spawn anywhere within the study area. They leave the area long before they reach adulthood, so much so that they are seldom taken in angler cacthes. During the cold wave of December 12, 1957, Lane snappers in large numbers were driven to deeper holes in Florida Bay where they lay, apparently numbed. No dead were observed in Florida Bay, however, several were found dead in Cleawater Pass (Whitewater VII to IX) on the 13th and 14th of December, 1957. OSR 13-47
OTR 16-29

Ocyurus chrysurus (Bloch) Yellowtail Snapper
Rare in the mudy shallows of north Florida Bay. One specimen 5.5 cm in length collected in Joe Kemp Channel in December, 1957, and another 7.2 cm in length taken in the same locality in October, 1958.
OSR 31-33
OTR 21-25

Family Centrarchidae (Sunfishes)

The sunfishes probably do not belong in a list of the fishes from brackish and marine waters. They are abundant members of the fresh-waters immediately adjacent to the mangrove habitat in the study area however, and are found in association with some of the euryhaline species. The sunfishes also move back and forth through the marginal area between brackish and fresh waters with the seasonal fluctuations in run-off and may be caught as adults during the peak rainfall periods in areas that a few months later, due to evaporation will be salty enough to sustain small redfish, ladyfish, snook and small spotted seatrout. Rotenone collecting stations along the highway to Flamingo

were sampled during 1958 and 1959 in the dry seasons of winter and series of sunfishes were secured. They have been preserved and placed in the fish collection of The Marine Laboratory for the convenience of persons interested in these fishes. A list of species collected follows:

Chaenobryttus gulosus (Cuvier)	Warmouth
Lepomis macrochirus Rafinesque	Bluegill
Lepomis microlophus (Günther)	Redear Sunfish
Lepomis punctatus (Valenciennes)	Spotted Sunfish
Micropterus salmoides (Lacépède)	Largemouth Bass

Family Rachycentridae (Cobias)

Rachycentron canadum (Linnaeus) Cobia

Rare in the study area. Observed once around range marker #2 off Cape Sable in October, 1958.

Family Carangidae (Jacks)

Caranx crysos (Mitchill) Blue Runner

Uncommon in the muddy water between Snake Bight and East Cape Sable. Occasionally taken by anglers off Sand Key and off the shoreline between Middle Cape Sable and the Shark River.

Caranx hippos (Linnaeus) Crevalle Jack

Very abundant in the marine and brackish water of the study area. Collected throughout the year. Most abundant in Coot and Whitewater Bays through the period June through November. No specimens smaller than 24 cm collected or observed. Jacks invade the brackish bays and the canals emptying the bays, in large numbers each fall from August through October. Most are large fish. At that time they feed wildly along the shorelines on larval fishes, mostly ladyfish and anchovies, and on the multitudes of cyprinodont fishes that have been driven from the surrounding swamps by low oxygen concentrations. Many are caught by anglers who tend to regard the jack as a nuisance since they take considerable time to land on light tackle when other species are seemingly more desirable. OSR 6-39
OTR 18-32

Chloroscombrus chrysurus (Linnaeus) Bumper

Uncommon in the study area but probably more abundant to the west and south of Cape Sable. Taken twice at Conchie Channel and off East Cape Sable during November, 1958. OS 30-31
OT 27-28

Oligoplites saurus (Bloch and Schneider) Leather Jacket
A common fish of the muddy waters off Flamingo as well as the deeper water off Cape Sable. Enters Coot Bay and Whitewater Bay during the fall and winter. Uncommon in the latter areas except near tidal inlets. It is often observed in large numbers feeding under outdoor flood lights at Flamingo. The species feeds heavily on bay snapping shrimp, *Alpheus heterochaelis,* small pink shrimp and larval anchovies and ladyfish. The smallest specimen collected was 30 mm in length and the largest 120 mm. OSR 31-44
OTR 27-31

Selene vomer (Linnaeus) Lookdown
Uncommon in the survey area. Colected twice, in October and November, 1958, at Sandy Key Basin and East Cape Sable respectively. Probably a common resident of the deeper waters south and west of Cape Sable as are the pompano. OSR 31-33
OTR 26-27

Trachinotus carolinus (Linnaeus) Pompano
Not observed or collected in the survey area. This species is the subject of an extensive trammel net fishery in Florida Bay that centers roughly ten to twelve miles off the Shark River.

Vomer setapinnis (Mitchill) Atlantic Moonfish
Collected once by night trawling in Sandy Key Basin in October, 1958.

Family Gerridae (Mojarras)

Diapterus plumieri (Cuvier) Striped Mojarra
The common mojarra of brackish to fresh water. Found most commonly in the marginal brackish to fresh environment inhabited by sunfishes, bullheads, ladyfish, and snook. Abundant in the mangrove swamps of the upper reaches of Hells Bay and thence eastward through the tributaries to West and Cuthbert Lakes and the Lungs. It may grow to lengths of 35 cm or more and a weight of three pounds although usually less. It feeds almost entirely by browsing along submerged banks and oyster bars. Large numbers of striped mojarra were killed by total oxygen depletion following hurricane DONNA, in the Nine-mile Bend area of the Everglades Park highway to Flamingo.
OSR 0-18

Eucinostomus argenteus Baird and Girard Spotfin Mojarra
The common, and very abundant mojarra of deeper waters of Florida

Bay. Essentially a species of high salinities. Collected the year around in all Florida Bay stations with the smallest individuals being taken in late summer and through the fall months. Was taken in Coot Bay and Buttonwood Canal during night collecting in May, August and December, 1958 and 1959. OSR 26-40
OTR 19-28

Eucinostomus gula (Quoy and Gaimard) Silver Jenny
The second most abundant mojarra of the high salinity areas of Florida Bay, also occuring in brackish water but not as abundantly as the following species. Collected the year around at all Florida Bay stations with a peak in numbers during the period September through November. Largest numbers of young, two to four cm, taken May through July. OSR 9; 17-35
OTR 16-31

Gerres cinereus (Walbaum) Yellowfin Mojarra
The most abundant mojarra in the study area since it occurs in large numbers in Coot and Whitewater Bays as well as off-shore. Peak trawl catches taken during the period December through April. Taken regularly at all Florida Bay trawling stations during 24 consecutive months, and in Coot Bay and Whitewater Bay at stations I, V, VI, VII, VIII, Oyster and Mud Bays and the Shark River when salinities are above 15‰. Least abundant in the bays during the period December through February. OSR 11-38
OTR 16-29

Family Pomadasyidae (Grunts)

Anisotremus virginicus (Linnaeus) Porkfish
Rare in the study area. Five young specimens collected on October 29, 1958, in Sandy Key Basin by trawling. UMML 5197. OS 34
OT 25

Haemulon aurolineatum Cuvier Tomtate
Single specimens, or small series, all less than 4 cm in length taken occasionally in trawl catches in clear water at Whitewater Bay stations VII and VIII, Sandy Key Basin and on the vegetated flats at Joe Kemp stations I through IV. Never common. OSR 20-37
OTR 19-28

Haemulon plumieri (Lacépède) White Grunt
The common grunt of Florida Bay and stations VII through IX in

western Whitewater Bay. Juveniles only. The largest specimen 53 mm in length. Occurs most commonly over *Thalassia* beds in clearer water.
OSR 18-33
OTR 15-27

Haemulon sciurus (Shaw) Bluestriped Grunt
Uncommon in the study area. Never taken as adults. Occurs most abundantly in Sandy Key Basin and in Clearwater Pass during the period September through November and again during the period March through June. Definitely a species of clear water, associated with heavy growths of red and brown algae species. Probably more abundant in the deeper water of the sponge grounds off the Shark River.
OSR 18-37
OTR 20-27

Orthopristis chrysopterus (Linnaeus) Pigfish
The abundant grunt of muddy bottoms and turbid water of the Joe Kemp-Conchie Channel area. Only rarely enters Coot and western Whitewater Bays. The only grunt collected as adults in the two years of this survey. Adults to 26 cm collected in large numbers during the cold winter of 1957-58. Large individuals most common in the months of September through March. Juveniles collected in Coot Bay, Clearwater Pass in western Whitewater Bay and in Joe Kemp and Conchie Channels during July through October. No spawning condition noted in the adults collected.
OSR 6; 18-38

Family Sciaenidae (Drums)

Bairdiella chrysura (Lacépède) Silver Perch
The most abundant sciaenid of the study area. It was collected in large series throughout the year and in all but the lowest salinity areas of eastern Whitewater Bay (stations II through IV). Much of this material has been housed in The Marine Laboratory collection as UMML 4739, 5009, 5215, 5991, 6674, 6860 and 2994. There are added series of specimens that have not as yet been cataloged. Large, fully mature specimens running milt and ripe eggs were collected in Conchie Channel on February 28, 1959. Juveniles from one to five centimeters abundant in hauls during the period March through June. No specimen approaching spawning size was found in Coot and Whitewater Bays. Spawning adults occur most abundantly in the deeper water of the channels off Flamingo and Cape Sable. The juveniles apparently enter the Coot Bay-western Whitewater Bay area when they are about two centimeters in length. Silver perch move out

of the inner bays at the onset of severe winter cold spells but quickly move back into the shallow bays at first warming. OSR 9-48
OTR 17-30

Cynoscion nebulosus (Cuvier) Spotted Seatrout

An abundant species throughout the study area. Although practically euryhaline, it is limited in its distribution in the study area, between Whitewater Bay stations III and VI, by a scarcity of food during periods of low salinity. Caught at all stations in Florida Bay but most abundant in the clear water of Snake Bight, the Jimmy's Lake area, south of Palm Key and in Sandy Key Basin. It also abounds in western Whitewater Bay in the Clearwater Pass area. This species is much sought after by anglers. Rosen and Dobkin (1959) conducted a survey of the sport fishery centered at Flamingo. They found that during the period March through September, 1958, anglers spent 24,000 fisherman days in the area. Thirty one per cent of these anglers came specifically to fish for spotted seatrout. In the seven months covered by the survey in 1958, anglers out of Flamingo caught 3,491 seatrout of which 3,022 or 86.6 per cent were above the legal minimum total lengths of 12 inches. The only species that was taken in greater numbers during that period were gray snappers, *Lutjanus griseus,* 5,512 of which were caught and 90.1 per cent of which were retained by the anglers. With increasing time for the fishermen to become familiar with the spotted seatrout habits and areas of best catches, the numbers of fish landed increased. Higman and Stewart (1961) estimated that 30,700 anglers fished out of Flamingo during the period July 1, 1959, through June 30, 1960. These anglers took 94,700 spotted seatrout for a total estimated weight of ~~1.4 million~~ 140 thousand pounds. During that year, spotted seatrout landings exceeded that of gray snapper. They suggest that the reversal of ranking between seatrout and snapper is due largely to the greater familiarity of the anglers with the habits of the fish and the generally more desirable nature of the seatrout for sport and food. Rosen and Dobkin (op cit) had stated that more seatrout were taken in the vicinity of the Florida Keys than in the Flamingo area. If this is a normal characteristic of the area from year to year, the total angler catch from Florida Bay, of seatrout, must exceed ~~3,000,000~~ 300,000 pounds a year at the present time. Higman and Stewart (op cit) reported that commercial fishermen took 250,000 pounds of spotted seatrout from waters within the boundaries of Everglades National Park during the period September, 1959, through August, 1960.

Stewart (1961) found by studying gonad maturation stages that some ripe fish were present throughout the year. The low point in numbers of ripe fish examined was during the months of October through March and the peak of spawning apparently took place during the period May through August. This coincides with the findings of the writers who captured large samples of running ripe males and females during the months of May and June both in 1958 and 1959. Although this report covers two full years of very extensive collecting throughout all the various environmental niches in the study area, and Stewart's study adds an additional period of several months bracketing the peak spawning period, only four young-of-the-year spotted seatrout were collected. These ranged between 2.5 and 10.5 cm total length. The 2.5 cm specimen was collected at Joe Kemp Channel station T3 on October 10, 1959. Two others, 8.5 and 10 cm long were collected in Tarpon Creek at the west end of Coot Bay on October 10, 1957, and at Whitewater Bay station VIII in Clearwater Pass on October 23, 1960. The fourth specimen, 10.5 cm in length, was taken at Buttonwood IV on April 13,1959. The very small numbers of young-of-the-year spotted seatrout taken during an extensive collecting program leads to the supposition that they may not spawn successfully in the area or at least did not do so during the period covered by the above mentioned surveys. This idea is further strengthened by the known fact that small spotted seatrout are among the easiest fish to collect with trawls if they are abundant in an area. A third bit of evidence to support the idea of very limited spawning in the area around Flamingo is suggested by the fact that such a high percentage of the seatrout taken by anglers are "keeper" size. In other very productive areas such as the Banana and Indian Rivers of east Florida and the Pine Island Sound fishery of southwest Florida, undersized seatrout are so abundant as to be a nuisance. This is not true in the study area, although fishermen occasionally find seatrout of 20 to 25 cm abundant for a time in the Shark River-Oyster Bay area and in some of the brackish ponds such as West and Bear Lakes.

Stewart (1961) aged the spotted seatrout by the scale mark method and concluded that they grew slightly more rapidly than seatrout further north on the west Florida coast, but less rapidly than those from the Indian and Banana River system of the central-east Florida coast. At Flamingo, males grew an average of 12.8 cm and females 13.6 cm in standard length in the first year. In the second year, males reached 20.8 cm and females 23.7 cm. In the third year males grew

to 26.2 cm while females increased their size advantage by growing to 28.1 cm. In the fourth year males averaged 30.8 cm and females 24.2 cm. In the fifth year males reached 34.4 cm and females 40.0 cm. Stewart failed to find any males older than five years of age. Females went on to seven years, averaging 43.5 cm in their sixth, and 45.2 cm in their seventh years.

Higman and Stewart (1961) and Stewart (1961) examined the stomachs of spotted seatrout from the Flamingo area and found that pink shrimp, *Penaeus duorarum,* made up 81.8 per cent of the total food items by number and 60.2 per cent by volume. Fish constituted 12.1 per cent by number and 32.9 per cent by volume. Porcellanid crabs made up 3.0 per cent of the total number and 5.6 per cent in volume. Caridean shrimp also made up 3.0 per cent by number but only 0.3 per cent by volume. Miscellaneous marine vegetation and shell fragments, obviously picked up in capturing their prey, made up 1.1 per cent of the total volume.

It is always interesting to obtain observations on mass mortalities of animals. Three times during the course of the survey period or shortly thereafter, spotted seatrout mortalities as well as that for other species were observed. During the freeze of December 12, 1957, several dead spotted seatrout were collected in Coot Bay and in eastern Whitewater Bay between stations I and V. Bottom water temperatures in the bay fell to about 12°C. The cold wave hit the area with great speed and force, and was brought in with high winds from the northwest which quickly chilled the shallows. A similar cold wave in February, 1958, did no damage so far as the reports of fishermen and our observations show. Higman and Stewart (1961) reported mortaility of small spotted seatrout in Bear Lake and in the Snake Bight and Cape Sable areas. Air temperatures at the time of the second freeze were as low as 30°F. The third mortality was that caused by hurricane DONNA of September 9, 1960. There was an extensive initial mortality of marine animals including spotted seatrout as a direct result of storm stranding and turbulence in the shallow bays with an attendant stirring of marl mud that packed gill chambers. In some areas, notably the mangrove zone from Snake Bight to mid-Whitewater Bay, the storm was followed by a prolonged period of total oxygen depletion. Masses of fish were thus killed that had survived the storm wave and siltation. Spotted seatrout remains were

abundant, floating on the surface for more than a week after the storm had passed. OSR 6-38
OTR 12-29

Equetes lanceolatus (Linnaeus) Jackknife-fish
Very rare in the survey area. Two specimens collected in Sandy Key Basin on October 29, 1958. OS 34
OT 28

Leiostomus xanthurus Lacépède Spot
An example of a species that appeared suddenly in the study area following the cold winter of 1957-58. From September, 1957, through March, 1958, no specimens had been taken. The first was collected in Conchie Channel station T3 on April 11, 1958. Following that, specimens were collected as follows: April 24, 1958, 11 from Conchie Channel; October 29, 1958, two specimens from Sandy Key Basin; November 11, 1958, two adults from off the mouth of East Cape Sable Canal; May 12, 1959, three specimens from Joe Kemp Channel stations T2 and T3 and the last specimen was taken in Tarpon Creek, western Coot Bay, on March 27, 1960. All specimens listed were adult or large juveniles. There has been no evidence of successful spawning in the study area by this species. UMML 6470 and 4871. OSR 9-48
OTR 24-27

Micropogon undulatus (Linnaeus) Atlantic Croaker
Rare in the study area, this species has been collected only three times and in all instances, captures followed cold weather of near record intensity suggesting that the croakers may move into the Flamingo region from farthern north to escape severe winter weather. Two collections were made in Conchie Channel in March and April, 1958, and in Tarpon Creek in March, 1960. OSR 19-32
OTR 24-27

Pogonias cromis (Linnaeus) Black Drum
Rather common in the soft muddy bottoms off Cape Sable Canal and in the western half of Whitewater Bay. Occasional in Coot Bay and the shallow brackish ponds east of Coot Bay. Taken regularly in small numbers by anglers chiefly during the fall and winter months. A single male 54 cm in total length was examined and found to be running large quantities of milt on November 11, 1958. OSR 10-31
OTR 20-28

Sciaenops ocellata (Linnaeus) Red Drum
A common sciaenid of all areas in northern Florida Bay. Slightly more

than three per cent of the 600 anglers interviewed by Rosen and Dobkin (1958) traveled to Flamingo to fish expressly for red drum or red fish. Three hundred and ninety eight red drum were caught by anglers at Flamingo during the period January through September, 1958. Higman and Stewart (1961) interviewed 3,267 anglers during the period July, 1959, through June, 1960, and found that 7.9 per cent of these anglers went to Flamingo expressly to fish for red drum. It is obvious that the increased percentages of anglers going for this species is a result of increasing familiarity with the area and a spreading of the word that red drum are available in the Flamingo fishery. Higman and Stewart (op cit) state that 36,000 pounds of red drum were caught within the boundaries of Everglades National Park by commercial fishermen in the 1959-60 period. Seven juvenile red drum were collected in May, 1959, in a roadside culvert pool (Poison station 1) at Coot Bay Pond. These fish were between 7 and 12 cm in length. They were collected with a series of small tarpon and fingerling striped mullet in water having a salinity value of 5‰ and temperature of 21°C. OSR 5-38
OTR 20-29

Vacuoqua sialis (Jordan and Eigenmann) Blue Croaker
One of the strange examples of frequent occurrence of a fish species that formerly was thought to be extremely rare. Twenty-three specimens collected and are now housed in The Marine Laboratory collection where they are being examined by Dr. C. R. Robins in preparation for taxonomic studies. The status of this species is in some doubt and it appears as though it might logically belong in the genus *Bairdiella*. Collected in the Sandy Key Basin area in clear water less than five feet in depth. Taken in both day and night otter-trawl samples. The relatively small numbers collected do not represent its true abundance, rather they indicate few samples from the Sandy Key area which is largely outside the regular sampling area. It was taken singly or in small lots of two or three whenever the trawl was towed over specific locations. Apparently feeds heavily on the abundant caridean shrimp and other crustaceans associated with dense red and brown algae clumps. Of the seven separate lots collected, three were taken during January, one in March, one in October and two in December. UMML 5087 and 4363. OSR 27-35
OTR 15-25

Family Sparidae (Porgies)

Archosargus probatocephalus (Walbaum) Sheepshead

Common, but not abundant in the study area. Large specimens taken by anglers in the Joe Kemp-Conchie Channel region off Flamingo and smaller individuals to be found along the mangrove shorelines of Coot, Whitewater and Oyster Bays. This species feeds upon porcellanid and xanthid crabs, and on the barnacles of the area, as well as upon plant material. There is no indication of spawning in the study area. The smallest specimen collected (7.5 cm) was taken in six feet of water on sandy bottom two miles southeast of East Cape Sable in October, 1958. UMML 5074. OSR 18-32
OTR 20-26

Calamus arctifrons Goode and Bean Grass Porgy
An abundant species on the *Thalassia* flats from the beginning of the survey in June, 1957, through the spring of 1959. Has been uncommon in the area since that time probably as a result of heavy siltation and turbidities along the belt of shoreline between Joe Kemp Key and East Cape Sable that have increased with a progressive dying of *Thalassia,* and boat traffic that tends to open the intertidal flats to current scouring. Grass porgies were taken in 13 regular monthly collections in the Joe Kemp, and Conchie Channel area and in Sandy Key Basin. Occasional in western Whitewater Bay. None were collected in Coot or eastern Whitewater Bays. Most of the specimens collected were juveniles 7 to 10 cm in length. Largest numbers were taken during the months of October through April. Five samples are housed in The Marine Laboratory collection as UMML 2996, 3035, 4868, 5020 and 5118. Other material is available but not catalogued. OSR 29-34
OTR 15-27

Lagodon rhomboides (Linnaeus) Pinfish
Probably the most abundant spiny-rayed fish of the shallows throughout the study area. Collected in every haul with nets in Florida Bay and in all but two areas (Whitewater stations III and IV) in Whitewater and Coot Bays. Length frequency distributions of pinfish taken in various areas are shown in Figue 7. This figure shows the time of entry of the smallest specimens, one to four centimeters in length, into the area. There is a tendency for the smallest fish to move to the shallower waters of Joe Kemp Channel and western Whitewater Bay in the warmer months. During winter, the majority of the pinfish are to be found in the deeper waters of Florida Bay from Conchie Channel westward. There is no indication that pinfish spawn in the inshore waters, but the small size of the juveniles in the collection suggests that

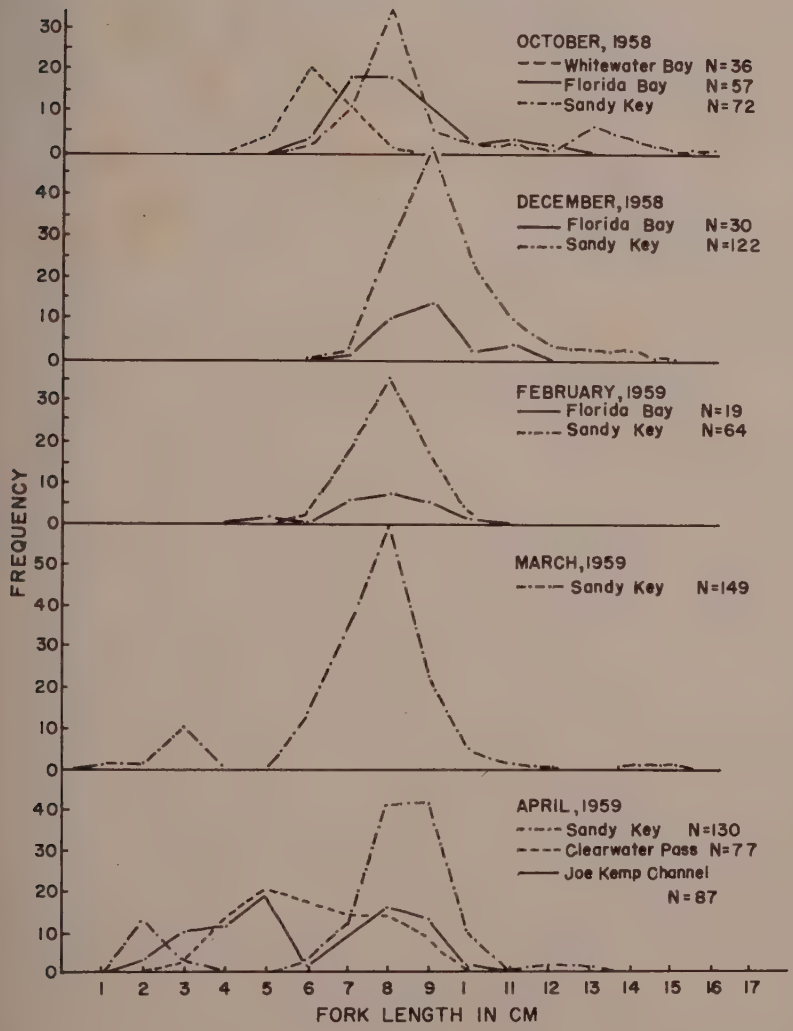

FIGURE 7. Length-frequency distributions for pinfish, *Lagodon rhomboides*, samples at various places and times to illustrate the time of recruitment of young of the year into collections.

the spawning sites must be relatively close. The smallest specimens collected (one cm), were taken in March and April. The largest pinfish collected was 16 cm fork length. Figure 8 presents the scatter of

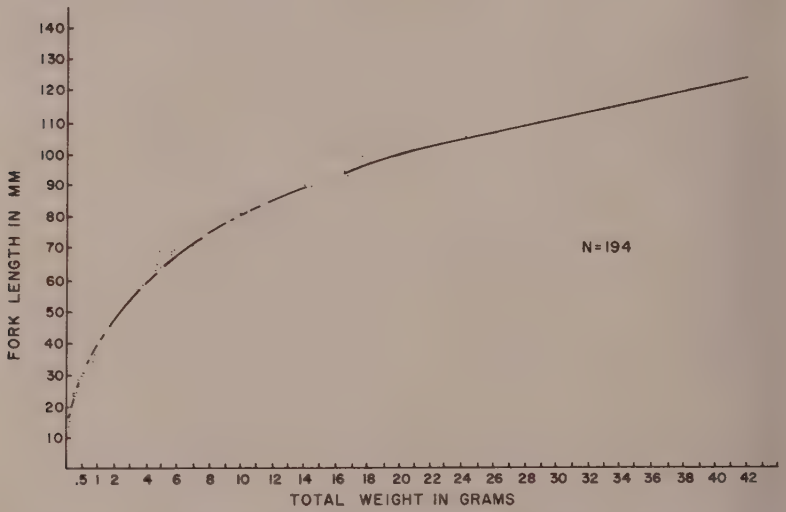

FIGURE 8. Fork length-total length relationship for pinfish, *Lagodon rhomboides*, taken in Florida Bay at Flamingo, Everglades National Park in April, 1959.

fish length against fish weight. Although the curve begins to level off at about 10 cm in length and 14-17 grams, growth in length and weight continues upward to the limit of at least 16 cm. OSR 8; 16-37 OTR 16-30

Family EPHIPPIDAE (Spadefishes)

Chaetodipterus faber (Broussonet) Atlantic Spadefish

Rather common in Florida Bay and enters Coot and Whitewater Bays on the flood tides. Collected on six separate occasions all in Florida Bay between Joe Kemp Key and Sandy Key Basin. Juveniles and adults most common in late fall and in winter. OSR 31-35 OTR 18-27

Family LABRIDAE (Wrasses)

Lachnolaimus maximus (Walbaum) Hogfish

Collected only as young, six to 12 cm, on five different occasions,

January, February and April, 1958, and in December, 1959. All the collections were made over the *Thalassia* flats between Joe Kemp and Sandy Key Basin. Not common in this area although much more so in the vicinity of the Florida Keys. OSR 31-35
OTR 18-27

Family SCARIDAE (Parrotfishes)

Nicholsina usta (Valenciennes) Emerald Parrotfish
Moderately common in the clear water of *Thalassia* flats from Joe Kemp Key to Sandy Key Basin and beyond. Was collected in Clearwater Pass on January 15, 1958, when salinities had risen to 20.6‰. Both adults and juveniles have been collected in Sandy Key Basin and off Cape Sable. Only juveniles have been collected in Joe Kemp and Conchie Channels and in Clearwater Pass. OSR 21-35
OTR 19-27

Sparisoma rubripinne (Valenciennes) Redfin Parrotfish
Collected four different times during May and October, 1958, and January and April, 1959. Collected only in the channels between Joe Kemp Key and Sandy Key Basin. Seemingly restricted to clearer water and marine salinities. OSR 32-37
OTR 15-27

Family SCOMBRIDAE (Mackerels and Tunas)

Scomberomorus cavalla (Cuvier) King Mackerel
Not taken strictly within the confines of the present study, but occurs in abundance, in the winter months, in the deeper waters south and west of Cape Sable. This and the following species are the source of a fairly large seasonal fishery in the waters off southwest Florida.

Scomberomorus maculatus (Mitchill) Spanish Mackerel
Very abundant off-shore in the western sector of the study area during the fall and winter. Rosen and Dobkin (1958) state that this species comprises 1.3 per cent of the total catch of 32 species taken by sport anglers fishing out of Flamingo during January through September, 1958. Spanish mackerel have been observed in the Shark River on numerous occasions where they were feeding on late fall and early winter seaward migrations of pink shrimp. Although abundant at such times they are practically impossible to catch. They enter the Shark River on the flood tides, penetrating as far as Cormorant Pass and Rocky Channel on the west and south edge of Whitewater Bay, and

retreat on the ebb tide to just off the mouth of the Shark River. Surface feeding activity has been observed both in the day and at night.

OSR 28-37
OTR 17-22

Family Eleotridae (Sleepers)

Dormitator maculatus (Bloch) Fat Sleeper

One small series collected at Poison station 1, Coot Bay Pond, on May 12, 1959. Probably common in the deep mangrove swamps in the area where brackish and fresh water meet. OSR 0-4
OT 21

Family Gobiidae (Gobies)

Gobionellus smaragdus (Valenciennes) Emerald Goby

The third ranked goby in point of numbers taken in brackish water collections. This species occurs uniformly throughout the deeper water of the mangrove zone and into Florida Bay high salinities as well. The largest specimens observed were six to 12 cm in length. These were found dead and dying as a result of oxygen depletion following hurricane DONNA on September 12 through 17, 1960. May be found in the same pool with tadpole madtoms, largemouth bass, striped mojarra and small tarpon, as well as with the larger species of the bays and off shore areas. Euryhaline. Most abundant in coarse shell or pitted rocky bottoms. OSR 0-37
OTR 24-27

Gobiosoma robustum Ginsburg Code Goby

The common and most abundant goby of the survey area. Found principally in vegetated areas and in greatest abundance in *Diplanthera* and *Ruppia* patches. Collected at all stations in Coot and Whitewater Bays except directly in the Shark River channel. Present but uncommon in the deeper water off Cape Sable, but abundant in the soft mud bottoms along shore from East Cape Canal to and including Snake Bight. A fish that is often eaten by smaller sizes of spotted seatrout, *Cynoscion nebulosus*. OSR 4-31
OTR 16-28

Lophogobius cyprinoides (Pallas) Crested Goby

Collected and observed in the Clearwater Pass area of Whitewater Bay, in the oyster bar community of Oyster Bay, in the pitted limestone bottoms of the channels of the rivers entering northern Whitewater

Bay. Can tolerate a sufficiently wide range of salinity to be classed as euryhaline, but is most abundant in the oyster community where salinities are normally in the upper limits of the brackish to marine environment. Some of the material has been entered in The Marine Laboratory collection as UMML 5542 and 6871. OSR 0-30
OTR 24-28

Microgobius gulosus (Girard) Clown Goby
Apparently second in numbers to *Gobiosoma robustum* in brackish areas. None was collected in Florida Bay in spite of intensive collections. Collections were made at all Coot and Whitewater Bay stations; at poison stations 1 through 7 along the Park highway; in Bear and West Lakes and in the Homestead Canal between Coot Bay Pond and Flamingo. Commonly taken with *Gambusia, Mollienesia,* small tarpon and snook. Not as restricted by bottom character, apparently, as the preceding species. Found in and around barnacle clumps on mangrove roots, in coarse rock along man-made embankments and in swamp pools containing only coarse wood and leaf fragments. UMML 2101, 3874, 3367, 4480, 5095, 5411, 6469 and 7021. Other collections are available but unsorted. OSR 0-32
OTR 16-29

Family Scorpaenidae (Scorpionfishes)

Scorpaena brasiliensis Cuvier Barbfish
Very rare in the study area. Probably more abundant in the sponge bottoms west and south of Cape Sable. Collected three different times as single specimens. One was taken on March 11, 1958, in Sandy Key Basin. The second was collected on May 14, 1959, in Sandy Key Basin and the third was collected in Oyster Bay on October 23, 1960. The three specimens were all small, between 4 and 7 cm. OSR 18-48
OTR 23-29

Family Triglidae (Searobins)

Bellator egretta (Goode and Bean) Streamer Searobin
Rare. A single specimen collected in Joe Kemp Channel on October 18, 1958. OS 36
OT 26

Prionotus scitulus Jordan and Gilbert Leopard Searobin
Collected six times during the course of the survey, all from Florida Bay. An inhabitant of deeper channels through the survey area, it

moves on to adjacent *Thalassia* flats and bare mud bars at night. The size range of the specimens collected was between four and 22 cm.
OSR 31-35
OTR 17-27

Prionotus tribulus Cuvier — Bighead Searobin
The most abundant searobin in samples. This is one of the species that frequents the higher salinity portions of Coot and Whitewater Bays during the summer and at the onset of cold weather, joins other fishes in a seaward migration. Taken at 10 regular collecting stations, one of which (Buttonwood IV) produced half of the specimens all during the winter movement. Specimens were also taken at Whitewater Bay stations VII and VIII, Joe Kemp Channel and Sandy Key Basin. UMML 5101, 5102, 5104, 5105, 5088 and 5092. OSR 11; 18-32
OTR 16-29

Family Clinidae (Clinids)

Paraclinus marmoratus (Steindachner) — Marbled Blenny
Rare during the survey period and another example of a species that was collected only in Sandy Key Basin. Two specimens were collected, one on February 10, 1959, and the other on March 11, 1959. Collected in a massive trawl haul of red and brown algae, on marl bottom heavily strewn with shell fragments. Taken with *Vacuoqua sialis* in both instances. OSR 33-34
OTR 25

Family Blenniidae (Combtooth Blennies)

Blennius marmoreus Poey — Seaweed Blenny
Collected once in Sandy Key Basin on February 10, 1959. OS 35
OT 25

Chasmodes saburrae Jordan and Gilbert — Florida Blenny
The common brackish-water blenny of the survey area. Collected only twice in salinities above 30‰, both in Conchie Channel, once on January 14, 1958, and once on May 8, 1958. All other collections made in Whitewater Bay with the greatest numbers coming from the Clearwater Pass-Oyster Bay complex. They are dominant animals in the oyster reef and oyster clump environment. Found most abundantly in clear water, often in areas of swift currents. Two series of specimens were used by Springer (1959) in his studies on the genus *Chasmodes*. He also comments on certain morphological differences between

Whitewater Bay specimens and those from other areas (Springer and Woodburn, 1960). OSR 0; 10-27; 33

Hypsoblennius hentzi (LeSueur) Feather Blenny

One specimen collected on November 6, 1959, in Joe Kemp Channel. UMML 5751. OS 31
OT 27

Family Sphyraenidae (Barracudas)

Sphyraena barracuda (Walbaum) Great Barracuda

Uncommon in the study area. Collected only two times in the period covered by this study, once in Tarpon Creek, west Coot Bay, on October 10, 1957, and in a tidal channel east of Oyster Bay on September 17, 1958. Both specimens were small, 12 and 34 cm fork length respectively. Their scarcity in our sampling is matched by a similar scarcity of this species in angler catches from northern Florida Bay. Because of these two facts, it is felt that sampling probably is representative of true abundance in this instance. No logical explanation is available to explain such scarcity. OSR 25-38
OTR 28-30

Family Mugilidae (Mullets)

Mugil curema Valenciennes White Mullet

The common small mullet of Florida Bay. Very abundant. This species supports a sizeable net fishery (Mefford, 1955). Mefford also discussed the aspects of the biology of the species in south Florida. Juveniles and "fingerlings" abundant in Coot and Whitewater Bays during the period May through October. Schools of this and the following species may mix when in small bays, however, there is a tendency for them to school separately in the open waters of Florida Bay. Both species create dense "muds" when feeding on muddy bottoms. Apparently does not frequent waters with as low salinity values as does the following species. OSR 12-39
OTR 16-30

Mugil cephalus Linnaeus Striped Mullet

Striped mullet are common throughout the survey area. Adults move into the shallow waters of Coot Bay and Whitewater Bay as well as those of the banks off-shore in the evening. During the daylight hours they retreat to deeper channels. Adults move into Coot Bay and similar areas in large numbers in April and May. They feed most actively in these areas throughout the summer and fall and then move out

rather suddenly in November and December with the first cold weather. They accumulate in Coot Bay and Coot Bay Pond at night in such great quantities that a searchlight beam played across the water causes a startling panic reaction in which all fish in the bay will rush madly through the water in a "steamroller" fashion. Striped mullet feeding on soft, bare mud bottoms, such as those of Coot Bay and Coot Bay Pond, create conical depressions 18 to 20 inches in diameter and two to four inches in depth which serve to concentrate flocculent material and small aquatic life much as the sand trap of the "ant lion" of sandy terrestrial situations does. The mullet visit these depressions many times each night and stand on their heads to graze the bottoms. As they feed in this manner, they rotate slowly in a clockwise direction and the expulsion of inedible material is jetted out through their gill chambers and deposited around the perimeters of the depressions. These feeding pits are not always evident to an observer on the water because of the generally turbid condition in these shallows. They are clearly visible to observers in a low flying plane, however. Higman and Stewart (1961) estimate that about 1,500,000 pounds of mullet were produced in the Everglades National Park waters during the period July, 1950, through June, 1960. OSR 0-37
OTR 19-34

Family ATHERINIDAE (Silversides)

Membras martinica (Valenciennes) Rough Silverside
Rare. One specimen collected in Joe Kemp Channel on the night of September 27, 1958.

Menidia beryllina (Cope) Tidewater Silverside
The common, and very abundant atherinid of the brackish waters of Everglades National Park. The larvae of this species taken in plankton tows in each month of the year. Adults congregate under lights in dense schools, particularly during the late summer and fall.
OSR 17-26
OTR 16-31

Menidia menidia (Linnaeus) Atlantic Silverside
The common silverside of higher salinities in Florida Bay. May enter areas such as Coot and Whitewater Bays on the tidal influx but leaves on the ebb tide. OSR 25-33
OTR 17-30

Family BOTHIDAE (Lefteye Flounders)

Ancylopsetta quadrocellata Gill — Ocellated Flounder
One specimen 18 cm in length collected on the firm shell-sand bottom at the range light off East Cape Sable on September 14, 1958. UMML 3689. Rare in the study area although anglers occasionally catch them. OS 35
OT 32

Etropus crossotus Jordan and Gilbert — Fringed Flounder
Collected on shell sand and muddy sand bottom five different times. Three were taken in Conchie Channel on April 11, October 30 and on November 11, 1958. Another was collected off East Cape Sable on November 10, 1958. The fifth specimen was captured in Oyster Bay on October 17, 1958, at the lowest observed salinity for this species, 25‰. Probably more common on the sandy bottoms just west of the survey area. OSR 25-32
OTR 25-27

Paralichthys lethostigma Jordan and Gilbert — Southern Flounder
This and the following species are the two large flounders of the survey area. Both have been found only in the deeper water from Conchie Channel to Cape Sable and thence west and south. Found on shell sand and firm marl bottom. Two specimens 30 and 38 cm were collected in October, 1959, in otter trawl hauls in Conchie Channel. Sometimes caught by anglers in small quantities off the sandy beaches of Cape Sable. OSR 32-37

Paralichthys squamilentus Jordan and Gilbert — Broad Flounder
Collected once on muddy sand bottom off the mouth of East Cape Canal in January, 1958. OS 34

Family SOLEIDAE (Soles)

Achirus lineatus (Linnaeus) — Lined Sole
The most abundant flatfish of the survey area. Aparently in greatest abundance in the inner bays and in a narrow band of muddy bottom along the Florida Bay shoreline. Adults seldom collected in the inner bays but common in Florida Bay. Smallest (one to two centimenters) specimens most abundant during the period October through February. Spawning probably takes place in Florida Bay not far from shore and not in the inner bays since the young appear suddenly in catches at about one centimeter total length. Massive off-shore movements of this and the following species occur each year in the months

of November through January. During this migration individuals of all sizes except adults above 12 cm may be collected in large series. They move on the surface as well as in mid-water, and are often eaten by large tarpon and snook. The soles apparently move back into the bays in the spring, but they are never taken in the canals on the outgoing period as they are in the winter exit. Large series have been housed in The Marine Laboratory along with collections of the following species for the convenience of interested persons. OSR 0; 11-40
OTR 17-30

Trinectes maculatus (Bloch and Schneider) Hogchoker
Occurs in the brackish bays with the preceding species and participates in the winter exodus in company with *A. lineatus,* but is much less abundant there. Unlike the preceding species, adults were collected in Coot Bay and Clearwater Pass as well as off-shore in Sandy Key Basin and the deeper water off Cape Sable. Strangely, few individuals of this species smaller than eight centimeters have been collected at any time. OSR 0; 10-35
OTR 18-29

Family CYNOGLOSSIDAE (Tonguefishes)

Symphurus plagiusa (Linnaeus) Blackcheek Tonguefish
Moderately common on the soft mud and shell sand bottom of Florida Bay. Occasionally taken in Oyster Bay and Clearwater Pass in western Whitewater Bay. Collected twice at Buttonwood IV, once in January and once in April, 1959. One specimen two centimeters in length collected in Coot Bay in March, 1958. Collected in Florida Bay in Sandy Key Basin and in the soft bottom between East Cape Sable and Flamingo. Many small specimens, two to five centimeters in length, killed by oxygen depletion in the Flamingo area following hurricane DONNA in September, 1960. OSR 17-38
OTR 16; 22-27

Order ECHENEIFORMES (Discocephali)
Family ECHENEIDAE (Remoras)

Echeneis naucrates Linnaeus Sharksucker
Never abundant, it is however, often seen in the study area. Enters the brackish inner bays on the tidal cycle, usually with large fish or turtles. Has been seen attached to striped mullet, green and loggerhead turtles and blacktip sharks. During a shrimp tagging experiment in Clearwater Pass in November, 1959, many sharksuckers were ob-

served around the houseboat from which the tagging operation was conducted. Endures low salinities for several days with no apparent discomfort. OSR 11-35
OTR 25-35

Order GOBIESOCIFORMES (Xenopterygii)
Family GOBIESOCIDAE (Clingfishes)

Gobiesox strumosus Cope Skilletfish
Only one specimen collected, in Buttonwood Canal at night on February 21, 1959, on the ebbing tide. It is not possible to say if this is a truly rare species in the survey area since it frequents areas difficult to collect with nets of any sort.

Order TETRAODONTIFORMES (Plectognathi)
Family BALISTIDAE (Triggerfishes and Filefishes)

Alutera schoepfi (Walbaum) Orange Filefish
Three specimens 18 to 30 cm taken in frame trawl at night in Sandy Key Basin on October 30, 1958. Rare except in that area and the deeper water further south and west.

Monacanthus ciliatus (Mitchill) Fringed Filefish
The common filefish of higher salinities in Florida Bay. Taken with the following species there in about equal numbers but *M. hispidus* may tolerate lower salinities. Always closely associated with vegetated areas, particularly *Thalassia*. Was collected in Coot and eastern Whitewater Bays in December, 1957, when salinities were 17.7‰. Collected in Clearwater Pass in November and December, 1958, when salinities were 10.3-13.6 and 17.3‰ respectively. Another collection of small specimens was taken in Clearwater Pass in April, 1959, when salinity values were between 19 and 26‰. All other collections (28) were made in the area between Snake Bight and Sandy Key Basin, where salinities were above 32‰. OSR 10-17; 32-37
OTR 15-26

Monacanthus hispidus (Linnaeus) Planehead Filefish
Abundant in Florida Bay at all stations in vegetated areas and common in western Whitewater Bay in the algae growths there. This and the preceding species occur most abundantly in clear water. Of twenty collections made at regular sampling stations where salinities and temperatures were taken, 17 were taken in salinities above 25‰. One sample was taken in Clearwater Pass when salinities were 14‰.

The smallest specimens collected were two centimeters long. The largest were six to eight centimeters long. Taken the year around in Florida Bay. OSR 14; 25-38
OTR 15-27

Family Ostraciidae (Trunkfishes)

Lactophrys tricornis (Linnaeus) Cowfish
Fairly common in Florida Bay on the *Thalassia* flats. Most abundant in the winter months when Florida Bay water tends to be somewhat less turbid. Collected only once in Clearwater Pass on April 22, 1958, when salinity values were between 16 and 19‰. All other collections made in salinities higher than 30‰. No specimens larger than 12 cm were collected in the survey area hence it is believed that this species as well as many of the others listed do not spawn near shore, but spawn in other localities and the young move in to take advantage of the rich feeding conditions available. OSR 16; 30-35

Family Tetraodontidae (Puffers)

Sphaeroides nephelus (Goode and Bean) Southern Puffer
The common large puffer of the area from the low salinities of eastern Whitewater Bay to the high salinities of Sandy Key Basin. A nuisance to anglers in Coot and Whitewater Bays. Reaches large size in the area. They move off-shore in November and December. At that time, young between two and five centimeters are common in night dipnet catches in the tidal channels. OSR 10-40
OTR 19-28

Sphaeroides spengleri (Bloch) Bandtail Puffer
This puffer seems, though it is difficult to prove, to be more abundant in the inner bays than the preceeding species and less abundant off-shore in Florida Bay. Seven out of 19 collections made at regular collecting stations where salinities were between 14 and 20‰. The remainder were collected in Florida Bay high salinities. Never observed to grow as large in the area as *S. nephelus*. OSR 14; 16-35
OTR 17-30

Family Diodontidae (Porcupinefishes)

Chilomycterus schoepfii (Walbaum) Striped Burrfish
Very common in moderately high to full strength sea salinities. All stations in Florida Bay and in the Shark River, Oyster Bay, Clearwater Pass and Coot Bay during winters when inner bays become moderately

salty. Intimately associated with vegetated areas, most abundant in shallow, clear water. Reaches a length of 15 cm in Florida Bay.
OSR 16; 20-47
OTR 15-28

Diodon hystrix Linnaeus — Porcupinefish
One specimen collected in Conchie Channel. Rare.

Order BATRACHOIDIFORMES (Haplodoci)
Family BATRACHOIDIDAE (Toadfishes)

Opsanus beta (Goode and Bean) — Gulf Toadfish
Abundant from the brackish lakes of the mangrove zone to the above normal salinities of Florida Bay. All stations. The species reaches full sexual maturity in the inner as well as outer bays and spawns through the summer and fall. One of the easiest fish to trap since, on muddy bottoms, they quickly enter any sort of dark box. One species that has profited by the invention of the beer can since they quickly appropriate the cans when rust has eaten out the ends. A fish to respect when it is guarding its nest cavity. Remarkably hardy. The senior author has kept them out of water for a full eight hours (at night) after collecting them from normal sea salinities, and then revived them in fresh water. Practically euryhaline. Alters its basic coloration to match its background. When crowded or guarding its nest, will gape and bluff an intruder.
OSR 6-47
OTR 15-30

Order LOPHIIFORMES (Pediculati)
Family OGCOCEPHALIDAE (Batfishes)

Ogcocephalus nasutus (Valenciennes) — Shortnose Batfish
Apparently rare in the survey area at all times although single specimens have been collected at nearly all stations in deeper water over coarse shell-sand of Conchie Channel and Sandy Key Basin. Samples ranged between 10 and 25 cm in length.
OSR 29-39
OTR 18-26

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